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# THESIS

CALCULATION OF ATMOSPHERIC TRANSMITTANCE
BY IBM 3033 COMPUTER CODE LOWTRAN IIIB

by

Moon-Sik Shin

June 1983

Thesis Advisor: Alfred W. Cooper

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Comparisons of NPS LOWTRAN IIIB computations with direct optical extinctions measurement over Monterey Bay and at San Nicolas Island indicate that under these circumstances LOWTRAN IIIB underestimates the extinction due to aerosols while the computed molecular absorption is in substantial agreement with experiment.

LOWTRAN IIIB is presently available as a method of predicting atmospheric transmittance at low resolutions at NPS and is suitable for incorporation in simulations and studies of electro-optic weapon/sensor systems performance.

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# Calculation of Atmospheric Transmittance by IBM 3033 Computer Code LOWTRAN IIIB

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Submitted in partial fulfillment of the
requirements for the degree of

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# ABSTRACT

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LOWTRAN IIIB is presently available as a method for predicting atmospheric transmittance at low resolution at NPS and is suitable for incorporation in simulations and studies of electro-optic weapon/sensor systems performance.

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# I. INTRODUCTION

LOWTRAN IIIB is a FORTRAN computer program, developed at the U.S.Air Force Geophysics Laboratory (AFGL), which was received in the modified form developed by Naval Weapon Center. It calculates the transmittance of the earth's atmosphere in the spectral region from 0.25 to 28.57 micrometers (350 to 40,000 cm-1) at 20 cm-1 spectral resolution on a linear wavenumber scale. Six atmospheric models, which are tropical, midlatitude summer and winter, subartic summer and winter, and the U.S. 1962 standard atmosphere, covering seasonal and latitudinal variations from sea level to 100 km are available, in addition to a capability of allowing the user to input atmospheric parameters of his own choosing. The program includes four aerosol models which are average continental, urban, rural, and maritime, and either hazy (5 km visibility) or clear (23 km visibility) haze conditions can be selected in addition to the capability of selecting a particular visibility of the user's choosing. The model accounts for molecular absorption, molecular scattering, and aerosol extinction, plus atmospheric refraction and earth curvature effects.

LOWTRAN IIIB is presently an available method for predicting atmospheric transmittance at low resolution at NPS and may be incorporated in simulations and studies of electro-optic weapon/sensor systems performance.

Basically, this thesis describes a program to

a) Develop a computer code to calculate atmospheric transmittance for particular wavelengths.

b) Develop a code to give transmittance and molecular absorptance with bandwidth appropriate to grey-body sources.

c) Apply these to prediction of transmittance over a marine optical path, based on the available meteorological data base for the area, for conditions appropriate to the optical propagation experimental measurement program at the Naval Postgraduate School.

## II. THEORY OF ATMOSPHERIC TRANSMITTANCE

Beer's law for linear propagation of monochromatic radiation in the linear regime can be expressed as follows;

$$\frac{d}{dz}\left[I(\nu)\right] = -\mu(\nu)\, I(\nu) \qquad \text{(eqn 2.1)}$$

or

$$I(z) = I(0)\, e^{-\mu z} \qquad \text{(eqn 2.2)}$$

The ratio $\frac{I(z)}{I(0)}$ is defined as the transmittance T of the path of length z, and u is the total extinction coefficient which is the sum of the coefficients for total absorption and non-forward scattering

$$\mu = \mu_a + \mu_s$$

Both the scattering and absorption coefficients can be divided into components due to the molecules of the air and the aerosol particles suspended in it; i.e.

$$\mu_a = k_m + k_a$$

$$\mu_s = \sigma_m + \sigma_a$$

where $k_m$ = molecular absorption coefficient

$k_a$ = aerosol absorption coefficient

$\sigma_m$ = molecular scattering coefficient

$\sigma_a$ = aerosol scattering coefficient

The relative values of the four coefficients depend strongly on the density and molecular composition of the atmosphere and the composition, number density and size distribution of the aerosols. The order of importance in each of the important atmospheric transmission windows is shown in Table I [Ref. 2]. We note from this that scattering by both

molecules and aerosols is of greater importance in the visible, and absorption in the infrared (particularly 8 to 14 um). Since devices are designed to operate throughout these windows, it is important to predict the transmittance of the atmosphere as a function of wavelength and weather conditions. This prediction becomes a complex problem of computer modelling. The problem requires a definition of the composition, density and pressure of the atmospheric gases, together with the frequencies, line strengths and line widths of all the spectroscopic transitions of the gas molecules and the aerosol constituents, and the number, size

TABLE I

Optical Atmospheric Attenuation Coefficient

| Atmospheric window | Wavelength for EO systems (μm) | Attenuation Coefficients in order of importance |
|---|---|---|
| Visible | 0.4 - 0.7 | $\sigma_a$, $\sigma_m$, $K_a$ |
| Near Infrared | 0.7 - 1.2 | $\sigma_a$, $K_a$, $\sigma_m$, $K_m$ |
| Middle Infrared | 3.0 - 5.0 | $K_m$, $\sigma_a$, $K_a$, $\sigma_m$ |
| Far Infrared | 8.0 - 12.0 | $K_m$, $K_a$, $\sigma_a$ |

and composition distributions of the particles.

Over the entire wavelength range from visible to infrared the absorption by molecules, scattering by aerosols and absorption by aerosols are the dominant extinction mechanisms, and should be considered. In the "window" regions of good transmittance, the molecular line absorption is relatively small, and may in some regions be ignored. The remaining extinction in these regions is due to aerosol scattering (which varies only slowly with wavelength) and "continuum absorption" by the molecules.

## A. MOLECULAR ABSORPTION

To compute the monochromatic transmittance of the atmosphere, we must first obtain accurate data describing the frequencies, intensity and line shape of all absorption lines affecting the attenuation. These should be developed a compilation based on certain constraints dictated by atmospheric abundances if we need to develop this monochromatic capability.

The approach by AFGL is to calculate the transmittance at given wavelength for each transition having finite absorption at that wavelength for each of the molecules. The summation over all the molcules gives a monochromatic transmittance which is appropriate directly for laser propagation, but must be degraded by integration over finite bandwidth for low resolution predictions suitable to non-laser sources.

To calculate the transmittance $T = e^{-K_m Z}$, the absorption coefficient $K_m$ should be known as a function of frequency for each line.

The four essential line parameters for each line are the resonant frequency, $\nu_0$ (cm-1), the intensity per absorbing molecule, S(cm-1/molecule cm-2), the Lorentz line width parameter, $\alpha_0$ (cm-1/atm), the energy of the lower state, E"(cm-1), and the line half-with at half maximum, $\alpha$, which is proportional to the pressure. The frequency, $\nu_0$, is independent of both temperature and pressure. The molecular absorption coefficient is given by

$$K_m(\nu) = \frac{S\alpha}{\pi\left[(\nu-\nu_0)^2 - \alpha^2\right]} \qquad \text{(eqn 2.3)}$$

$$S = \int K_m(\nu)\, d\nu \qquad \text{(eqn 2.4)}$$

The pressure broadened line width depends in a complicated fashion on temperature; for computation this is approximated by the assumption of temperature - independent collision diameters, leading to

$$\mathcal{L} = \mathcal{L}(P_o, T_s) \frac{P}{P_o} \left(\frac{T_s}{T}\right)^{\frac{1}{2}} \qquad \text{(eqn 2.5)}$$

where P = 1 atm, and

T = 296 degrees Kelvin.

The intensity, S, is pressure-independent and its temperature dependence can be calculated from E" and

$$S(T) = S(T_s) \frac{Q_v(T_s)}{Q_v(T)} \times \frac{Q_r(T_s)}{Q_r(T)} \times \exp\left[1.439\ E''\left(\frac{T-T_s}{T T_s}\right)\right] \qquad \text{(eqn 2.6)}$$

where $Q_v$ and $Q_r$ are vibrational and rotational partition functions respectively. At lower pressure the collision broadening diminishes and Doppler broadening becomes important. In the intermediate pressure range the Voigt profile obtained by convolving the two profiles is used. Once Doppler broadening dominates the Gaussian profile may be used. Lorentz linewidths are typically .001 to .01 cm-1, while the Doppler width may be 0.0003 cm-1.

The AFCRL calculations [Ref. 14] are based on the Absorption Line Parameters Compilation, which originally listed $\nu_o$, S(T), $\mathcal{L}$(Ps, Ts) and E" for 130,000 lines in the range beyond 1 $\mu$m, for each one of the species water, carbon dioxide, ozone, nitrous oxide, carbon monoxide, methane and oxygen. A new version of the compilation including over 139,000 lines between 0.2 $\mu$m and 30 $\mu$m was recently reported by AFGL [Ref. 3].

## B. CONTINUUM ABSORPTION

Continuum absorption occurs as a result of collisional interactions between molecules; that is, collisions between two $H_2O$ molecules and those of other gases (principally $H_2O$: $N_2$ collision, since nitrogen comprises approximately 80 % of the air)

In wavelength regions between the absorption bands some attenuation occurs of a continuous nature which is attributed to water vapor. The mechanism of water vapor continuum extinction lacks a complete theoretical explanation. At present, it is believed that it results from the accumulated attenuations of the distant wings of $H_2O$ absorption lines, occurring principally in the far infrared part of the spectrum. Other postulates, such as that the phenomenon is caused by other absorption mechanisms involving $H_2O$ dimers, remain possibilities yet to be proved.

However, all that we can do at present is to account for the water vapor continuum phenomenon empirically, based on what limited experimental measurements we have to go on, until better line shape theories become available. It should be emphasized that further accurate and well controlled measurements are urgently required in order to account for this phenomenon in real atmospheric situations with confidence.

A common formulation used (for example in LOWTRAN IIIB) to account for the water vapor continuum attenuation at a fixed temperature has been to define the transmittance $\bar{T}(\nu)$ as follows;

$$\bar{T}(\nu) = e^{-K(\nu) \times \text{range}} \qquad \text{(eqn 2.7)}$$

where the attenuation coefficient $k(\nu)$ is given by

$$K(\nu) = C_S\left[P_{H_2O} + \frac{C_N}{C_S}(P_T - P_{H_2O})\right]\omega \qquad \text{(eqn 2.8)}$$

where $P_{H_2O}$ and $P_T$ refer to the water vapor partial pressure and ambient pressure respectively (atm), and $\omega$ defines the quantity of water vapor per unit pathlength (gm cm-2 km-1). The quantities $C_S$ and $C_N$ are generally referred to as the self and foreign (nitrogen) broadening coefficients for water vapor.

Values for $C_S$ and $C_N/C_S$ have been obtained empirically from laboratory measurements. In LOWTRAN versions I through III, the quantity $C_N/C_S$ is assumed to remain constant over a given wavelength interval. However, a major addition in LOWTRAN IIIB has been to account for the temperature dependence of Cs and this will be discussed in the 8-14 $\mu$m $H_2O$ continuum region. The $H_2O$ continuum radiation in the 3.5-4.2 $\mu$m region is of much less importance and will not be futher discussed here.

1. Temperature Dependence

The water vapor continuum attenuation coefficient has been found to have a significant temperature dependence, which was not accounted for in the previous LOWTRAN computer codes. Based on the laboratory measurements using samples of water vapor at elevated temperatures, an approximate empirical expression was obtained by Roberts et al [Ref. 6] for the temperature dependence which is given in Eqn 2.9 below. It was found that the attenuation coefficient due to the water vapor continuum increases as the temperature decreases. That is, for a fixed amount of water vapor in a given path, one would expect more absorption at lower temperatures and less absorption at higher temperatures. This is a somewhat unusual phenomenon. In practice one finds less water vapor in the atmosphere under cold conditions, therefore, the effect of temperature on the attenuation in

the 8-14 $\mu m$ region plays two competing roles, through the total water content of the path and the attenuation coefficient.

The empirical fits to the wavelength and temperature dependence of the water vapor continuum described in Roberts et al [Ref. 6] have been used in LOWTRAN IIIB with the appropriate conversion of units as follows.

The attenuation coefficient $C_S$ in $gm^{-1}\ cm^2\ atm^{-1}$ at 296 K is given by the following expression in the 8-14 $\mu m$ region:

$$C_S(\nu, 296) = 4.18 + 5578 \exp(-7.87 \times 10^{-3} \nu) \qquad \text{(eqn 2.9)}$$

where $\nu$ is the wavenumber in $cm^{-1}$ (note that $= 10^4/\lambda$, where $\lambda$ is the wavelength in $\mu m$).

The temperature dependence of the coefficient $C_S$ was found to vary as:

$$C_S(\nu, T) = C_S(\nu, 296) \exp 6.08 \left(\frac{296}{T} - 1\right) \qquad \text{(eqn 2.10)}$$

where T is the temperature in degrees Kelvin.

2. <u>Nitrogen Broadened Coefficient</u>

$C_N/C_S$ in the above Equation represents the ratio of the foreign (nitrogen) broadening coefficient to the self broadening coefficient.

In LOWTRAN IIIB we use a value of 0.002 for the parameter $C_N/C_S$ based on the measurements presented by Supplement LOWTRAN IIIB [Ref. 7].

Here, it is assumed that $C_N/C_S$ (at 296 K) does not vary with temperature (since no supporting measurements are available).

Thus, further measurements are needed to determine more accurately the magnitude of the parameter $C_N/C_S$ and its temperature and wavelength dependence.

3. Transmission Calculations

The transmittance due to the water vapor continuum in the 8-14 $\mu$m region is calculated for a horizontal path of length RANGE(km) at altitude z using the following expression in LOWTRAN IIIB:

$$T(\nu) = \exp\left[-C\ (\nu, 296) \times W(z) \times RANGE\right] \qquad \text{(eqn 2.11)}$$

where W(z) is the effective $H_2O$ absorber amount per unit path length (in gm · $cm^{-2}$ atm $km^{-1}$) at altitude z, and $C_S(\nu, 296)$ is the water vapor (self broadened) attenuation coefficient obtained from laboratory measurements at a temperature of 296 K.

The quantity W(z) is given by:

$$W(z) = w(z)\left[P_{H_2O} \exp\left[6.08\left(\frac{296}{T(z)}-1\right)+0.002\left(P_T-P_{H_2O}\right)\right]\right. \qquad \text{(eqn 2.12)}$$

where

w(z) = gm cm-2/km of H2O in the path at temperature T,

$P_{H_2O}$ = H2O partial pressure (atm) at altitude z,

$p_T$ = ambient (total) pressure (atm) at altitude z, and

T(z) = ambient temperature at altitude z (degrees Kelvin).

Note that the temperature dependence of the attenuation coefficient $C_S(\nu,T)$ given in Eqn 2.10, has been incorporated into the expression for W in Eqn 2.12. The reason for this

is so that the temperature variation over a given atmospheric slant path is weighted equally with the water content along the path.

It may be worth contrasting Eqn 2.12 with the corresponding expression which has been used in LOWTRAN I through LOWTRAN III, that is:

$$W(z) = w(z)\left[P_{H_2O} + 0.005(P_T - P_{H_2O})\right] \qquad \text{(eqn 2.13)}$$

## C. AEROSOL EXTINCTION COEFFICIENT & MODELS.

Scattering of radiation occurs from molecules in the air, from aerosol particles suspended in the air, and from water droplets in fog, rain or hail. The attenuation of a beam depends on the size and number density distribution and the refractive index of the particles. Atmospheric transmission may be strongly influenced or even dominated by scattering from aerosol particles. The major parameter determining the interaction is the ratio of particle radius to the wavelegth of the radiation.

### 1. Aerosol extinction coefficient

Aerosol extinction is sum of the absorption and scattering by aerosol particles. Although scattering by aerosol particles whose radius is smaller than about 0.03 times the wavelength of the light may be calculated by Rayleigh theory, for the whole range of particle radius Mie theory must be applied.

a. Rayleigh Scattering

The Rayleigh volume total scattering coefficient may be written as

$$\sigma_m = \frac{8\pi^3(n^2-1)^2}{3N\lambda^2}\left(\frac{6+3P}{6-7P}\right) \qquad \text{(eqn 2.14)}$$

where n ; refractive index

N ; the number density of molecules

P ; depolarization factor due to some molecular anisotropy.

Following Penndorf [Ref. 8] it can be written in the following form which depends on pressure and temperature.

$$\sigma_m = 9.807\times10^{-20}(273/T)(P/1013)\,\nu^{4.0117}\,Km^{-1} \qquad \text{(eqn 2.15)}$$

The strong dependence on wavelength means that Rayleigh scattering is a small effect for wavelengths longer than the visible.

b. Mie scattering

This is appropriate for the condition of particle size comparable to wavelength; i.e., for large molecules and small droplets. This is the most important mechanism for atmospheric scattering. McCartney gives the scattering coefficient [Ref. 9].

$$\sigma = \pi\int r^2 N_T(r)\,K(\alpha, n)\,dr \qquad \text{(eqn 2.16)}$$

where r ; the particle radius

$N_T(r)$ ; the total number density of particles in the size range dr about r

$K(\alpha, n)$ ; the area scattering coefficient, the ratio of effective area to geometrical area, which depends on $\alpha = 2\pi r/\lambda$ and refractive index n.

2. Aerosol Model

The range of conditions in the boundary layer is represented by three diffent aerosol models, which are rural, urban or maritime. The first two are grouped together as " averaged continental ".

a. Maritime

Maritime aerosol composition and size distributions are significantly different from rural and urban aerosol types. The maritime aerosol component is due to salt particles which are caused by the evaporation of seaspray a droplets. The concentration of particles near the surface is strongly dependent on wind speed ( above 7 m/sec ) and the size distribution is also dependent on relative humidity. This salt-particle number-density decreases rapidly above about 500 m [Ref. 10].

b. Rural

Rural aerosol background is partly the product of reactions between various gases in the atmosphare and partly due to dust particles picked up from the earth surface. The particle concentration is largely dependent on the history of the airmass carrying the aerosol particles.

c. Urban

Urban aerosols contain certain additives from combustion products and from industry. Shettle and Fenn assumed an addition of 35% soot-like particles of similiar distribution to the rural aerosol [Ref. 11].

## III. LOW RESOLUTION MODELLING

### A. MODEL ATMOSPHERES

The LOWTRAN code provides a choice of six atmospheric models. These include the 1962 U. S. Standard Atmosphere plus five supplementary models. Surface level conditions for the supplementary models are given in Table II [Ref. 1]. There are also two conditional haze models - corresponding to sea level visual ranges of 5 and 23 km - provided as basic input data for LOWTRAN III. Aerosol attenuation for other visual ranges is calculated using an interpolation/

TABLE II

Surface Level Condition for Model Atmospheres

| Model atmosphere | Latitude & month | Pressure (mb) | Temp. (K) | Air density (g/m3) | Water vapor (g/m3) | Ozone (g/m3) |
|---|---|---|---|---|---|---|
| Subartic | | | | | | |
| winter | 60 N,Jan | 1013 | 257 | 1372 | 1.2 | 4.1E-05 |
| summer | 60 N,July | 1010 | 287 | 1220 | 9.1 | 4.9E-05 |
| Midlatitude | | | | | | |
| winter | 45 N,Jan | 1018 | 272 | 1301 | 3.5 | 6.0E-05 |
| summer | 45 N,July | 1013 | 294 | 1191 | 14.0 | 6.0E-05 |
| Tropical | 15 N | 1013 | 300 | 1167 | 19.0 | 5.6E-05 |

extrapolation procedure which utilizes these two models. In addition to the model atmospheres the user has the option of inserting his own model atmosphere, or of building another model by combining various parts of the six standard models.

Provisions are made in the LOWTRAN program for inserting radiosonde data. There are limits on the accuracy of LOWTRAN transmittance calculations when the input is radiosonde data alone. Radiosondes provide vertical profiles of the synoptic meteorological parameters of temperature,

pressure, humidity, and wind. Information on micrometeorological parameters (i.e., aerosol size distributions, local oxidant concentrations, etc.) is also needed as input. In the absence of micrometeorological inputs LOWTRAN relies on its model atmospheres for that information; this may not necessarily be applicable to a specific location. For further discussion on optical parameters see [Ref. 12].

## E. CALCULATION MODELLING

In the application it is impossible to measure transmittance at a single frequency. Instead one measures the transmittance $T(\nu)$ averaged over the spectral bandwidth, $\overline{T}_{\Delta\nu}(\nu)$, accepted by the receiver, as indicated in the equation

$$\overline{T}_{\Delta\nu}(\nu) = \frac{1}{\Delta\nu}\int T(\nu)\, d\nu \qquad \text{(eqn 3.1)}$$

where $\nu$ is the central frequency in the interval, $\Delta\nu$. Consequently for many applications one is interested in knowing the transmittance of the atmosphere averaged over a relatively wide spectral interval, that is, for low resolution.

Thus the term transmittance is somewhat ambiguous unless it is qualified by some indication of the spectral resolution, $\Delta\nu$, over which it is averaged. This is particularly true in the case of molecular absorption, since the absorption coefficient $K_m$ is a rapidly varying function of frequency. It is because of the rapid variation of $K_m$ with frequency that the averaged tranmittance $\overline{T}$ does not, in general, obey the simple exponential law. That is,

$$\overline{T}_{\Delta\nu}(\nu) = \frac{1}{\Delta\nu}\int_{\Delta\nu} \exp\left[-K_m(\nu)\,\Delta m\right] \qquad \text{(eqn 3.2)}$$

where $K_m$ represents the net monochromatic molecular absorption coefficient. On the other hand the molecular scattering coefficient ($\sigma_m$) and the aerosol scattering and absorption coefficients($\sigma_a$ and $K_a$) are slowly varying functions of frequency, and the average transmittance obeys the simple exponential law provided only the direct transmitted beam is being observed

There are four basic approaches to obtaining a low resolution transmittance value for a given path through the atmosphere due to molecular absorption. These are;

(1) direct measurements over the required path,

(2) measurements in the laboratory under simulated conditions,

(3) line-by-line (monochromatic) calculations based on detailed knowledge of spectroscopic line parameters which are then averaged over the required spectral interval,and

(4) calculations based on band model techniques (which use available laboratory and/or field transmittance measurements or actual line data as a basis).

From the point of view of computations, method 3 involves a considerable amount of work and computer time, and consequently method 4 has been used most frequently.

Basically, it involves a graphical or computerized "curve fitting" technique for accessing the stored transmittance data for the appropriate absorber and scatterer amounts computed from the input atmospheric path conditions. The predetermined variations of transmittance with frequency are stored for the various atmospheric constituents, for standard path conditions.

For a given set of meteorological conditions and selected path, the appropriate absorber and scatterer amounts in the required path are computed for each component and the results used to correct the transmittances for these components. The transmittances for the separate processes

(line absorption, continuum absorption, molecular scattering, aerosol scattering and aerosol absorption) are then multiplied together to give the overall absorption. That is :

$$T_{\Delta\nu}(\nu)\,(\text{total}) = T_{\Delta\nu}(\nu)\,(\text{line absorption})\ \times$$
$$T_{\Delta\nu}(\nu)\,(\text{continuum absorption})\ \times$$
$$T_{\Delta\nu}(\nu)\,(\text{Rayleigh})\ \times$$
$$T_{\Delta\nu}(\nu)\,(\text{aerosol}).$$

It should be noted that the LOWTRAN computer code is designed to calculate the transmittance for spectral bands. It should not be used to calculate transmission for laser lines. Suitable techniques for computing atmospheric transmission for laser lines or extremely narrow spectral bands are described in [Ref. 13], [Ref. 14], and [Ref. 15].

# IV. EXAMPLE OF PROGRAM USE

## A. PROBLEM

As a check on the performance of the code a sample calculation was carried out using the same input data described by Shlanta and Cornette [Ref. 1], for which they provide computed output.

The example is the calculation of the transmittance from 2350 to 2450 cm-1 in steps of 5 cm-1 for a slant path from 2.5km to 8.5 km at a zenith angle of 65 degree, for a subartic winter model atmosphere, and a 23 km visual range.

The program is initiated with data input on 4 cards (lines) defining the conditions of the computation, and user directions are given at the beginning of the program listing (Appendix A).

```
CARD 1  **5**1**1
        5 ; Sub-artic winter atmosphere
        1 ; An average continental aerosol model
        1 ; For 23 km visible range
        0 ; For normal operation, etc.
CARD 2  **2**0*********2.500*****8.500****65.000
        2 ; Vertical & slant path between two altitudes
        0 ; For normal operation of the program which
            selects the shorter path when applicable
        2.500 ; Observer altitude (km)
        8.500 ; Source altitude (km)
        65.000 ; Zenith angle at H1 (deg.).
CARD 3  **2350.000**2450.000*****5.000
        2350.000 ; Initial frequency (cm-1)
        2450.000 ; Final frequency   ( " )
        5.000 ; Frequency intervals at which
                transmittance is printed.
```

CARD 4 **0

0 ; To end data.

## B. OUTPUT FROM LOWTRAN IIIB.

The output for this problem is given in Appendix C. The parameters defining the atmospheric path, model atmospheres and frequency range are first printed out. Following tabulations give the absorber amounts for horizontal and vertical path. At the heading HORIZONTAL PROFILES there are 13 columns. The first column gives a running integer associated with each level. The second column gives the level altitude in km. The next 8 columns give the equivalent absorber amounts per km for the following absorbing species: water vapor, uniformly mixed gas, ozone, nitrogen continuum, water vapor continuum (10 $\mu$m), molecular scattering, aerosol extinction and UV ozone, respectively. The next three columns give the mean refractive index modulus from that level to the level above, the equivalent absorber amounts per km for the water vapor continuum (4 $\mu$m) and for nitric acid.

A heading VERTICAL PROFILES is then printed followed by 15 columns. The first and second columns give the integer associated with the levels traversed by the path and the height of the level. Then follow 8 columns which give the integrated equivalent absorber amounts from the initial altitude to the level above (in the same order as indicated above). The next 4 columns are labelled PSI, PHI, BETA, and THETA (see Appendix D).

The total equivalent absorber amounts for each absorber species are then summarized below in their appropriate units.

The second line in the total equivalent absorber amount table gives the water vapor continuum amount (4 μm) and the nitric acid amount.

A transmittance table, containing 12 columns, now follows. The first 3 columns give the frequency (cm-1) wavelength (μm), and total transmittance. The next 7 columns show the individual transmittances due to water vapor, uniformly mixed gases, ozone, nitrogen (4 μm) continuum, total water vapor continuum, molecular scattering, and aerosol extinction. The last 2 columns give absorption due to aerosols and the cumulative integrated absorption. The latter quantity can be used to determine the average transmittance over any given spectral interval within the spectral range covered by the calculation. Finally, the total integrated absorption from V1 to V2 is printed out together with the average transmittance over the band.

## V. APPLICATION

The purpose of this implementation of LOWTRAN IIIB is to present a simple method of predicting atmospheric transmittance (at low resolution) which is applicable over a wide spectral interval and for a wide range of atmospheric path.

In this study the bandwidths of the computations have been chosen to match the transmission bands of the filters used by the atmospheric optics measurement group at NPS [Ref. 16]. These filters have been used with grey - body sources to give wavelength resolution in a number of trans-

TABLE III

Broadband System

| center wave-length (μm) | filter bandwidth at 1/2 ht (μm) | " (CM-1) | grey-body source temp. (K) | detector |
|---|---|---|---|---|
| 0.49 | .010 | 20619-21053 | 2800 | Si |
| 0.63 | .010 | 15748-16000 | " | " |
| 0.84 | .010 | 11834-11976 | " | " |
| 1.03 | .010 | 9662-9756 | " | " |
| 1.06 | .010 | 9390-9479 | " | " |
| 1.60 | .098 | 6064-6447 | " | " |
| 2.15 | .097 | 4549-4759 | " | Ge |
| 3.80 | .400 | 2500-2778 | 1800 | InSb, 77K |
| 3.835 | .110 | 2571-2646 | " | " |
| 10.66 | 2.850 | 827-1083 | " | HgCdTe, 77K |
| 11.02 | .710 | 879-938 | " | " |

mittance measurements at Monterey and elsewhere. Figure 5.1 shows the passbands of the grey-body source filters superimposed on curves of atmospheric transmittance for a 1000 ft, path at sea level containing 5.7 mm of precipitable water at 79°F. The filter bands are shown as Table III.

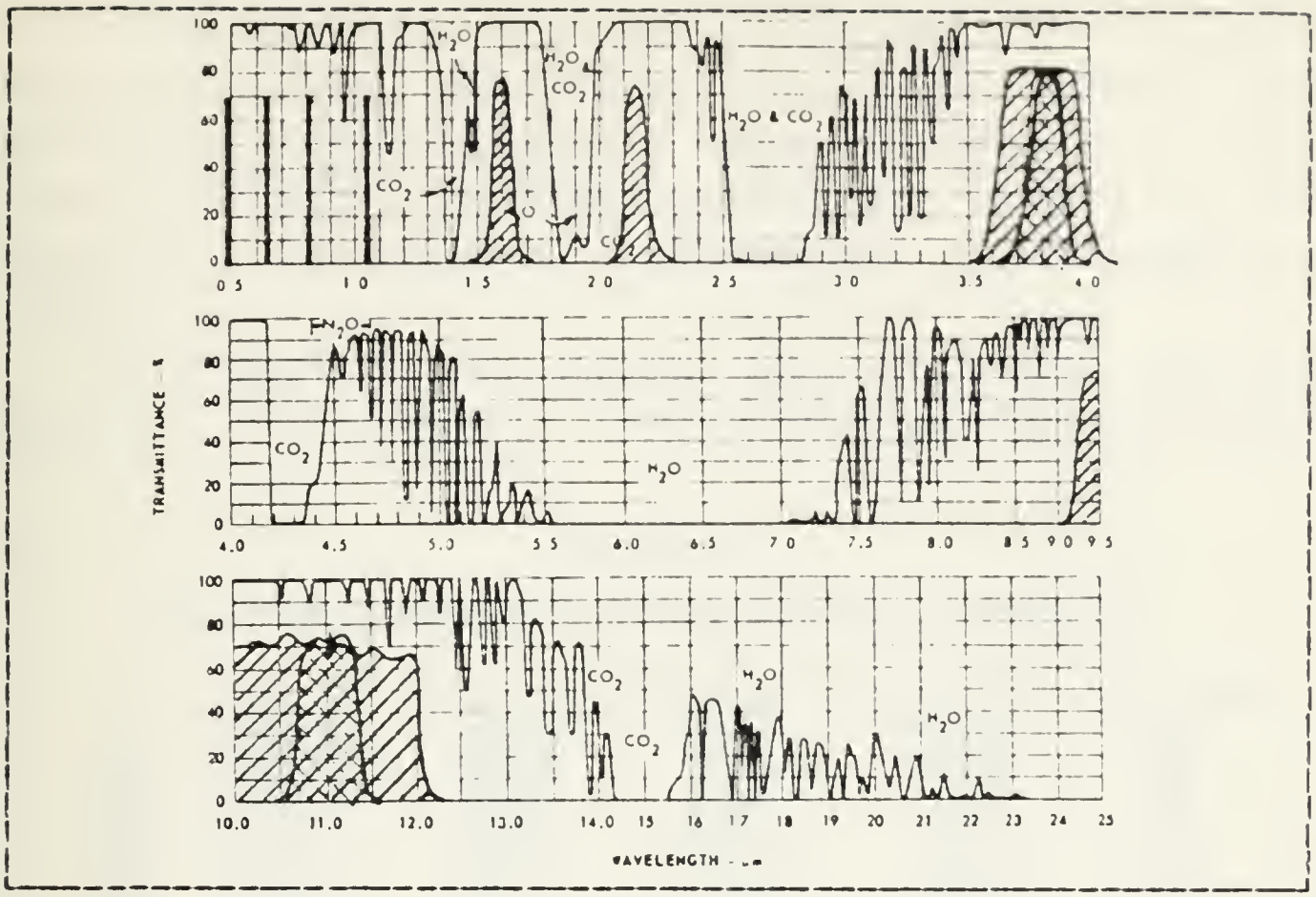


Figure 5.1 Bandpass Regions for Grey-body Source.

## A. LOWTRAN CALCULATIONS FOR THE MONTHLY AVERAGE DATA OF MONTEREY BAY

Calculations intended for use in the propagation studies in the Monterey Bay Area make use of the known range of conditions and three different relative humidities, 70, 80, and 90 %, taking into account the monthly and yearly averages of air pressure, air temperature, dewpoint temperature, water vapor density, and relative humidity. These monthly and yearly averages are taken from the thesis by Guner [Ref. 4], and ozone density is translated from that source to 6.00E-05 gm/m3, consistent with the midlatitude model in Table II. In this Table IV the average temperature is used which is the mean value of maximum and minimum average temperatures corresponding to day/night conditions.

Table V shows the calculated atmospheric transmittance for 3 different cases of relative humidities and temperatures for selected wavebands of the broadband system at sea level (1.60, 2.15, 3.80, 3.835, 10.66, 11.02 μm), 13.16 km range, and with typical May conditions. Figure 5.2 and Figure 5.3 also represent the atmospheric transmittance of Table V.

By comparing the numbers for different relative humidity, it can be seen that increasing relative humidity

TABLE IV

Monterey Bay Area Average Weather Condition

| | mean pr. (mbars) | mean temp. (deg.) | mean dew. (deg.) | H2O den. (gm/M ) | rel. hum. (%) |
|---|---|---|---|---|---|
| JAN. | 1020.0 | 10.03 | 6.12 | 7.37 | 77 |
| FEB. | 1020.0 | 10.57 | 6.68 | 7.67 | 76 |
| MAR. | 1017.5 | 10.84 | 6.68 | 7.67 | 78 |
| APR. | 1018.0 | 11.68 | 8.34 | 8.53 | 77 |
| MAY. | 1017.0 | 13.34 | 9.45 | 9.11 | 77 |
| JUN. | 1015.0 | 14.45 | 11.12 | 10.16 | 79 |
| JUL. | 1017.0 | 14.73 | 11.68 | 10.55 | 83 |
| AUG. | 1017.5 | 15.29 | 10.23 | 10.92 | 84 |
| SEP. | 1013.5 | 15.84 | 14.73 | 10.55 | 79 |
| OCT. | 1017.5 | 14.73 | 10.01 | 9.40 | 75 |
| NOV. | 1019.0 | 12.79 | 7.23 | 7.95 | 72 |
| DEC. | 1018.0 | 11.12 | 6.12 | 7.37 | 73 |
| YEAR. | 1017.5 | 13.07 | 8.89 | 8.82 | 77 |

TABLE V

Comparison of Transmittance by R.H & Temperature

| | wavenumber μm | cm-1 | Rel. Humidity 70 % | 80 % | 90 % | temperature (°C) 0.0 | 13.3 | 30.0 |
|---|---|---|---|---|---|---|---|---|
| (1) | 1.60 | 6064-6447 | .823 | .823 | .823 | .823 | .823 | .823 |
| (2) | 2.15 | 4549-4759 | .834 | .832 | .831 | .833 | .833 | .833 |
| (3) | 3.80 | 2500-2778 | .803 | .797 | .791 | .794 | .799 | .803 |
| (4) | 3.835 | 2571-2646 | .813 | .808 | .803 | .806 | .810 | .814 |
| (5) | 10.66 | 827-1083 | .836 | .815 | .793 | .801 | .821 | .839 |
| (6) | 11.02 | 879-938 | .856 | .833 | .808 | .818 | .840 | .860 |

decreases the atmospheric transmittance. We can also see that increasing temperature increases the transmittance;

significant differences of the transmittance occur due to temperature. The numbers from the 8-14 $\mu m$ region are much larger than the other band. This point is consistent with the theory of the temperature dependence from chapter II.

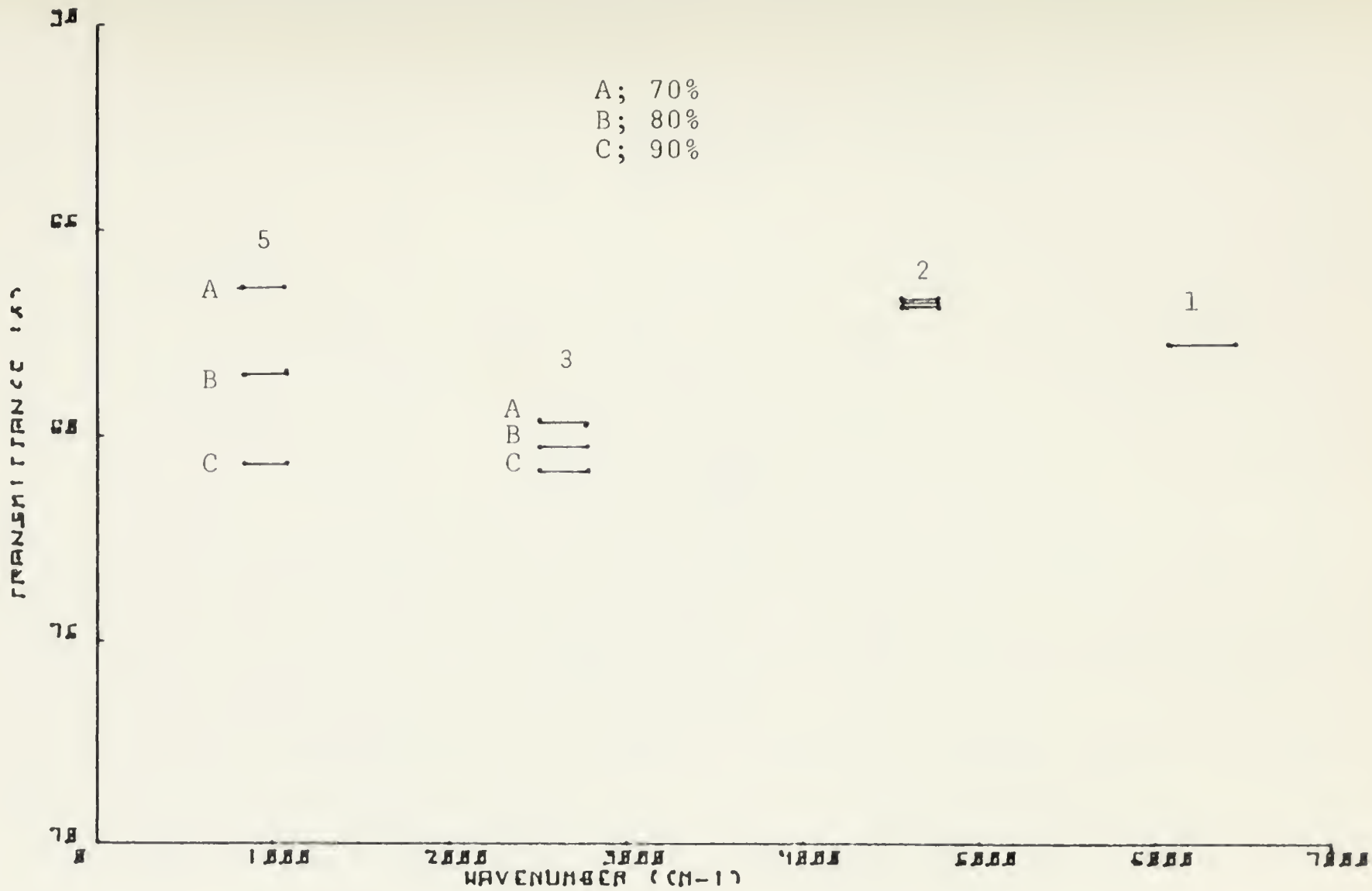


Figure 5.2 Comparison of Transmittance due to Relative Humidity.

Figure 5.3 Comparison of Transmittance due to Temperature.

## B. OPTICAL TRANSMISSION AT SAN NICOLAS ISLAND, CEWCOM-78.

In May 1978 the NPS Optical Physics and Micrometeorology Groups participated in a Cooperative Experiment, West Coast, Oceanography and Meteorology, 1978 (CEWCOM-78) in cooperation with the measurement program OSP-III run by the USN Optical Signatures Program on San Nicolas Island. Optical transmittance measurements from the R/V ACANIA to shore and micrometeorological measurements on the R/V ACANIA were made by NPS measurement group, and other meteorological data were monitored in the OSP experiment. Weather conditions limited the data obtained.

The measured transmittance of the optical path from the R/V ACANIA to site A on the northwest tip of San Nicolas

TABLE VI

San Nicolas Data, CEWCOM-78

| Date | Time | Range(m) | Broadband(μm) 3.6-4.0 | 9.0-12.0 |
|---|---|---|---|---|
| 5/15 | 1126 | | 63.0 %(94.99) | |
| " | 1458 | 2192 | | 45.2 %(96.14) |
| " | 1633 | 2200 | 57.8 %(95,31) | |
| " | 1649 | 2200 | | 49.8 %(96.63) |

Island is listed in Table VI. The transmittances are the observed values, uncorrected for the molecular absorption, measured with filter selection from a grey-body source.

The micrometeorological data taken by the NPS Meteorology Team during the CEWCOM-78 experiment [Ref. 16] and the Daily Statistical Summary of Meteorological Data [Ref. 17] are used to find interpolated temperature, relative humidity, and visibility. The numbers in parentheses represent LOWTRAN predictions of transmittance, including both molecules and aerosol extinction based on these meteorological input data.

The comparison is given for the one day for which suffi-

TABLE VII

Meteorological Data

| Time | Broadband (μm) | Press. (mbar) | Temp. (deg.) | Dew T. (deg.) | R.H. (%) | Water vapor (g/m3) |
|---|---|---|---|---|---|---|
| 1126 | 3.6-4.0 | 1013.2 | 14.52 | 10.0 | 81.0 | 9.8 |
| 1633 | " | " | 14.99 | 10.9 | 66.7 | " |
| 1458 | 9.0-12.0 | " | 14.80 | 10.9 | 74.67 | 9.7 |
| 1649 | " | " | 14.93 | 10.0 | 65.69 | 9.5 |

cient meteorological data are available (Table VII). This comparison shows the LOWTRAN predicted transmittance for these conditions to be much higher than the measurements. The overestimation of transmittance by LOWTRAN suggests that the particle model included in the code may be inadequate, or that the model's total particle number density may be underestimated by the code. Calibration errors in the measurement equipment have been investigated and are considered an unlikely source of the discrepancy.

## C. EXPERIMENTAL MEASUREMENT FROM MARINA TO POINT PINOS

The current modelling effort was undertaken in support of an experimental progam of transmittance measurement of total extinction on ranges over Monterey Bay from Marina to Point Pinos (June 1979) using laser and broadband (thermal) sources. The optical extinction was measured at 0.4880, 0.6328, 1.03, 1.06, and 11.05 μm.

The calculational program has therefore been directed to computation of molecular absorption and aerosol extinction coefficients for sea level propagation under a range of weather conditions statistically typical of Monterey. This has been done for a variety of wavelengths appropriate to the measurements, and averaged over the filter bandwidths for the broadband sources used (see Table III.).

The aerosol particle spectrum was measured on board the ACANIA with a Knollenberg counter. This information was used to predict a scattering extinction coefficient, based on one point measurement of the particle size spectrum.

For comparison of data it is necessary to subtract the effects of molecular absorption from the total optical

TABLE VIII

Extinction Coefficient from Optical Measurement and LOWTRAN

| date | time | (μm) | optical (a) | LOWTRAN total (b) | LOWTRAN molecular (c) | diff. (a-c) | aerosol (d) |
|---|---|---|---|---|---|---|---|
| 6/6 | 1734 | 1.60 | 22.5 | 2.47 | 0.072 | 22.4 | 31.6 |
| | 1714 | 1.06 | 21.7 | 2.68 | 0.165 | 21.5 | 32.4 |
| | 1718 | 1.03 | 19.4 | 2.69 | 2.63 | 16.8 | 32.8 |
| | 1720 | 0.84 | 22.1 | 2.75 | 0.196 | 21.9 | 32.8 |
| | 1721 | 0.63 | 22.5 | 2.83 | 0.066 | 22.4 | 32.8 |
| 6/7 | 1406 | 11.02 | 19.17 | 1.84 | 1.52 | 17.7 | 7.62 |
| | 1404 | 10.6 | 12.1 | 2.01 | 1.49 | 10.6 | 7.72 |
| | 1423 | 1.06 | 35.5 | 2.45 | 0.16 | 35.3 | 48.7 |
| | 1434 | 1.03 | 43.9 | 4.87 | 2.56 | 41.3 | 49.5 |
| | 1555 | 11.02 | 20.0 | 1.73 | 1.25 | 18.8 | 7.83 |
| | 1558 | 10.6 | 10.6 | 1.77 | 1.26 | 9.34 | 7.71 |
| | 1615 | 1.6 | 35.3 | 2.17 | 0.07 | 35.2 | 49.2 |
| | 1628 | 1.06 | 38.3 | 2.43 | 0.15 | 38.2 | 50.5 |
| | 1632 | 1.03 | 35.0 | 4.69 | 2.4 | 32.6 | 51.4 |
| | 1634 | 0.84 | 40.1 | 2.52 | 0.18 | 39.9 | 51.0 |
| | 1636 | 0.63 | 43.2 | 2.45 | 0.067 | 43.13 | 53.0 |

extinction. This is done using LOWTRAN. The value of relative humidity and water vapor content have been obtained from Prof. Schacher and Dr. Fairall who made the aerosol measurements [Ref. 18].

The results are presented in Table VIII. The extinction in units of E-02 km-1 as measured optically, the LOWTRAN prediction of total extinction, the molecular contribution computed by LOWTRAN, total measured minus LOWTRAN molecular, and the values calculated from aerosol spectra are shown.

By the comparison seen by the Table VIII, optical extinction computed from the aerosol spectra is much higher than the LOWTRAN total extinction, and is very often higher

than the measured optical extinction. This may be due to the fact that aerosol extinction was not measured over the whole path but at only one point. It was measured on board the ACANIA meteorological mast at a height of approximately 10 m above mean sea level, at approximately the centerpoint of the optical path. The optical path in this experiment ranged from 18.3 m above sea level at Marina to almost sea level at the ACANIA, due to earth curvature over the 13.16 km path.

Total aerosol extinction from LOWTRAN is much less than the extinction calculated from the measured aerosol spectrum. Subtracting the calculated molecular component of the LOWTRAN from the optically measured extinction yields the aerosol extinction ("diff."), which is much greater than the LOWTRAN aerosol component but somewhat less than that predicted from the aerosol spectra. i.e., agreement of aerosol extinction is much better with aerosol spectrum measurement than with the LOWTRAN aerosol extinction. It appears probable that the LOWTRAN model consistently underestimates the severity of aerosol extinction in the marine environment.

## VI. CONCLUSION AND RECOMMENDATION

The comparisons of LOWTRAN IIIB predictions with optical measurements and with computations from particle size distribution measurements show considerable differences. The differences could conceivably arise from measurement errors in the optical transmittance and the particle measurements; the two physical measurements give results reasonably close to each other but in both cases differ markedly from LOWTRAN IIIB. In view of the consideration give to both measurement techniques it seems most likely that LOWTRAN IIIB consistently underestimates the aerosol attenuation in the infrared wavebands

It must first be realized that LOWTRAN IIIB contains limitations. It does not include the effects of

1. clouds, fog or precipitation
2. refraction, scintillation or distortion of the propagating beam due to turbulence
3. background interference from direct or scattered solar radiation
4. surface level reflections and masking
5. multiple scattering

In addition the models of refraction and earth curvature are simplified and the atmosphere is considered to be horizontally homogeneous and stable with no inversion. These limitations mean that at best LOWTRAN IIIB results are of "moderate" accuracy.

Some of these limitations have been removed in the continuing evolution of LOWTRAN. LOWTRAN IV (Feb. 1978) in addition to using improved empirical transmittance functions for gases of small absorber amount, includes the effects of nitric acid as an absorber and emitter, and incorporates a

"radiance mode" to compute the radiance from the earth surface and the atmosphere.

LOWTRAN V (Feb, 1980) has been upgraded to include new aerosol models dependent on altitude and relative humidity, and a model for fog attenuation.

It may be expected that implementation of these codes (preferbly LOWTRAN V) may give better agreement between experiment and compution and allow better validation of aerosol extinction calculation methods.

LOWTRAN IV and LOWTRAN V are not currently available at NPS in card or tape form, and considerable modification will be required to adapt them to use on the IBM 3033 system. In the absence of later forms of LOWTRAN, the IIIB version may still be used to compare transmittances under different conditions. In addition, little change has been made in the absorption in later versions, so that the use of IIIB to compute the atmospheric absorption is valid. This allows its use to compute aerosol extinction from total optical extinction by subtraction of the calculated absorpton.

It is recommended that an effort should be made to adapt LOWTRAN V for the NPS IBM computer system.

```
C*****************************************************************
C*            NAVAL POSTGRADUATE SCHOOL MODIFICATION                *LL 00010
C*                    OF AFGL LOWTRAN 3B                            *LL 00020
C*                 (1 OCTOBER 1976 VERSION)                         *LL 00030
C*                                                                  *LL 00040
C*                  MAJ. MOON-SIK SHIN                              *LL 00050
C*                   AIR FORCE KOREA                                *LL 00060
C*                                                                  *LL 00070
C*****************************************************************LL 00080
C*                                                                  *LL 00090
C*     PROGRAM LOWTRAN 3B CALCULATES THE TRANSMITTANCE OF THE ATMOS-  *LL 00100
C*     PHERE FROM 350 CM-1 TO 40000 CM-1 (0.25 TO 28.57 MICRONS) AT   *LL 00110
C*     20 CM-1 SPECTRAL RESOLUTION ON A LINEAR WAVENUMBER SCALE.      *LL 00120
C*     REFRACTION AND EARTH-S CURVATURE EFFECTS ARE INCLUDED.         *LL 00130
C*     THE ATMOSPHERE IS LAYERED IN ONE KILOMETER INTERVALS BETWEEN   *LL 00140
C*     GROUND LEVEL AND 25 KM., 5 KM. INTERVALS TO 50 KM., A TWENTY   *LL 00150
C*     KM. INTERVAL TO 70 KM., AND A THIRTY KM. INTERVAL TO 100 KM.   *LL 00160
C*                                                                  *LL 00170
C*****************************************************************LL 00180
C*                                                                  *LL 00190
C*     PROGRAM ACTIVATED BY SUBMISSION OF FOUR CARD SEQUENCE'         *LL 00200
C*                                                                  *LL 00210
C**** CARD 1' MODEL,IAERO,IHAZE,JP,IM,M1,M2,M3,ML,RO,VIS             *LL 00220
C*                                      ------FORMAT(9I3,3X,2F10.3) ****LL 00230
C*                                                                  *LL 00240
C*     MODEL SELECTS ONE OF THE FOLLOWING MODEL ATMOSPHERE'           *LL 00250
C*        MODEL = 0 FOR HORIZ. PATH WHEN METEOROL. DATA USED'         *LL 00260
C*           INSTEAD OF CARD 2, READ H1,P(MB),T(DEG C),DEW PT.TEMP    *LL 00270
C*           (DEG C), REL. HUMIDITY(%),H2O DENSITY(GM.M-3),O3 DENSITY *LL 00280
C*           (GM.M-3), RANGE(KM)                                     *LL 00290
C*           ----------- FORMAT(3F10.3,2F5.2,2(1PE10.3),F10.3).     *LL 00300
C*        MODEL = 1 SPECIFIES A TROPICAL ATMOSPHERE.                 *LL 00310
C*        MODEL = 2 SPECIFIES A MIDLATITUDE SUMMER ATMOSPHERE.       *LL 00320
C*        MODEL = 3 SPECIFIES A MIDLATITUDE WINTER ATMOSPHERE.       *LL 00330
C*        MODEL = 4 SPECIFIES A SUB-ARCTIC SUMMER ATMOSPHERE.        *LL 00340
C*        MODEL = 5 SPECIFIES A SUB-ARCTIC WINTER ATMOSPHERE.        *LL 00350
C*        MODEL = 6 SPECIFIES A 1962 US STANDARD ATMOSPHERE.         *LL 00360
C*        MODEL = 7 FOR NEW MODEL ATMOSPHERE (E.G., RADIOSONDE DATA)' *LL 00370
C*           READ BETWEEN CARDS 1 AND 2, ALTITUDE(KM),P(MB),T(DEG C), *LL 00380
C*           DEW PT.TEMP(DEG C),REL. HUMIDITY (%),H2O DENSITY(GM.M-3), *LL 00390
C*           O3 DENSITY(GM.M-3), AEROSOL NO. DENSITY(CM-3)           *LL 00400
C*           ------------- FORMAT(3F10.3,2F5.2,2(1PE10.3),F10.3)    *LL 00410
C*           NOTE EITHER DEW PT.TEMP, REL. HUM., OR H2O DENSITY      *LL 00420
C*           CAN BE USED.                                            *LL 00430
C*                                                                  *LL 00440
C*     IAERO SELECTS THE TYPE OF AEROSOL ATTENUATION'                 *LL 00450
C*        IAERO = 1 SPECIFIES AN AVERAGE CONTINENTAL AEROSOL MODEL.   *LL 00460
```

```
C*        IAERO = 2 SPECIFIES A RURAL AEROSOL MODEL.                    *LL 00470
C*        IAERO = 3 SPECIFIES AN URBAN AEROSOL MODEL.                   *LL 00480
C*        IAERO = 4 SPECIFIES A MARITIME AEROSOL MODEL.                 *LL 00490
C*                                                                      *LL 00500
C*     IHAZE SELECTS THE DEGREE OF AEROSOL ATTENUATION'                 *LL 00510
C*        IF IHAZE=0 NO AEROSOL SCATTERING IS COMPUTED.                 *LL 00520
C*        IF IHAZE = 1 AND VIS IS NON-ZERO, THEN AEROSOL ATTENUATION    *LL 00530
C*           FOR THE VISIBLE RANGE IS USED.                             *LL 00540
C*        IF IHAZE = 1 OR 2 AND VIS IS ZERO, THEN AEROSOL ATTENUATION   *LL 00550
C*           FOR 23 KM AND 5 KM VISIBLE RANGES, RESPECTIVELY,           *LL 00560
C*           IS USED.                                                   *LL 00570
C*                                                                      *LL 00580
C*     JP SELECTS THE PRINT OPTION'                                     *LL 00590
C*        JP = 0 FOR NORMAL OPERATION.                                  *LL 00600
C*        JP = 1 TO SUPPRESS THE PRINTING OF THE TRANSMITTANCE TABLE.   *LL 00610
C*                                                                      *LL 00620
C*     IM DETERMINES WHEN RADIOSONDE DATA IS TO BE READ IN'             *LL 00630
C*        IM = 0 FOR NORMAL OPERATION.                                  *LL 00640
C*        IM = 1 FOR INITIALIZING RADIOSONDE OR METEOROLOGICAL          *LL 00650
C*           DATA.                                                      *LL 00660
C*                                                                      *LL 00670
C*     M1, M2, AND M3 ARE USED TO CHANGE TEMP, H2O, AND O3 ALTITUDE     *LL 00680
C*        PROFILES, RESPECTIVELY, TO ANOTHER MODEL VALUE.               *LL 00690
C*                                                                      *LL 00700
C*     ML IS THE NUMBER OF LEVELS OF RADIOSONDE DATA FOR MODEL = 7.     *LL 00710
C*                                                                      *LL 00720
C*     RO IS THE INPUT VALUE FOR THE RADIUS OF THE EARTH.  IF RO IS     *LL 00730
C*        ZERO THEN THE PROGRAM USES STORED VALUES.                     *LL 00740
C*                                                                      *LL 00750
C*     VIS IS THE VISUAL RANGE AT SEA LEVEL (KM)                        *LL 00760
C*                                                                      *LL 00770
C**** CARD 2' ITYPE,LEN,H1,H2,ANGLE,RANGE,BETA---FORMAT(2I3,4X,5F10.3) **LL 00780
C*                                                                      *LL 00790
C*     ITYPE INDICATES THE TYPE OF ATMOSPHERIC PATH'                    *LL 00800
C*        ITYPE = 1, CORRESPONDS TO A HORIZONTAL (CONSTANT PRESSURE)    *LL 00810
C*           PATH.  READ H1 AND RANGE.                                  *LL 00820
C*        ITYPE = 2, VERTICAL OR SLANT PATH BETWEEN TWO ALTITUDES.      *LL 00830
C*           READ H1 AND TWO OTHER GEOMETRIC PARAMETERS (E.G., H2 AND   *LL 00840
C*           ANGLE).                                                    *LL 00850
C*        ITYPE = 3, VERTICAL OR SLANT PATH TO SPACE.                   *LL 00860
C*           READ H1 AND ANGLE.                                         *LL 00870
C*                                                                      *LL 00880
C*     LEN SELECTS THE TYPE OF RAY PATH TO BE USED'                     *LL 00890
C*        LEN = 0 FOR NORMAL OPERATION OF THE PROGRAM WHICH SELECTS     *LL 00900
C*           THE SHORTER PATH WHEN APPLICABLE.                          *LL 00910
C*        LEN = 1 TO SELECT THE LONGER PATH WHEN APPLICABLE.            *LL 00920
C*                                                                      *LL 00930
```

```
C*     H1       =    OBSERVER ALTITUDE (KM)                                  *LL 00940
C*     H2       =    SOURCE  ALTITUDE (KM)                                   *LL 00950
C*     ANGLE    =    ZENITH ANGLE AT H1 (DEGREES)                            *LL 00960
C*     RANGE    =    PATH LENGTH (KM)                                        *LL 00970
C*     BETA     =    EARTH CENTRE ANGLE (DEGREES)                            *LL 00980
C*                                                                           *LL 00990
C**** CARD 3' V1,V2,DV----------------------------FORMAT(3F10.3)********LL 01000
C*                                                                           *LL 01010
C*     V1 = INITIAL FREQUENCY (WAVENUMBER CM-1) INTEGER VALUE                *LL 01020
C*     V2 = FINAL FREQUENCY(WAVENUMBER CM-1) INTEGER VALUE                   *LL 01030
C*     DV = FREQUENCY INTERVALS AT WHICH TRANSMITTANCE IS PRINTED            *LL 01040
C*        NOTE' DV MUST BE A MULTIPLE OF 5 CM-1                              *LL 01050
C*                                                                           *LL 01060
C**** CARD 4' IXY---------------------------------FORMAT(I3)***********LL 01070
C*                                                                           *LL 01080
C*     IXY IS THE CYCLING INDICATOR'                                         *LL 01090
C*        IXY = 0 TO END DATA                                                *LL 01100
C*        IXY = 1 FOR NEW CARD 3 ONLY                                        *LL 01110
C*        IXY = 2 TO CONTINUE DATA                                           *LL 01120
C*        IXY = 3 FOR NEW CARD 2 ONLY                                        *LL 01130
C*        IXY = 4 FOR NEW CARD 1 ONLY (PLUS RADIOSONDE OR                    *LL 01140
C*           METEOROLOGICAL DATA, IF DESIRED)                                *LL 01150
C*                                                                           *LL 01160
C*************************************************************************LL 01170
C                                                                            LL 01180
C                                                                            LL 01190
C  DATA SETSC3/C4/C5/C7/C7A/C207-09/ ARE READ IN AT BEGINNING                LL 01200
C    OF PRORRAM TO COMMON STORAGE DUE TO COMPILER STORAGE LIMITATIONS        LL 01210
C    WITH NPS COMPUTER.                                                      LL 01220
C                                                                            LL 01230
      COMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),Z0(34),P01(34),P02(34),        LL 01270
     *P03(34),P04(34),P05(34),P06(34),T01(34),T02(34),T03(34),T04(34),      LL 01280
     *T05(34),T06(34),WH01(34),WH02(34),WH03(34),WH04(34),WH05(34),         LL 01280
     *WH06(34), WO01(34),WO02(34),WO03(34),WO04(34),WO05(34),WO06(34),      LL 01280
     *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),         LL 01280
     *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),          LL 01280
     *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),          LL 01280
     *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),        LL 01280
     *C702(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),             LL 01280
     *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),                LL 01280
     *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)                   LL 01390
      DIMENSION          TX(10),VH(10),E(10),AHZ1(34),AHZ2(34),W(10),       LL 01400
     *                   P(7,34),T(7,34),WH(7,34),WO(7,34),VX(4,45),        LL 01410
     *                   C7(4,45),C7A(4,45),C1(2580),C2(1575)
C                                                                            LL 01420
      LOGICAL            CKZERO                                             LL 01430
      CKZERO(X)=ABS(X).LT.1.E-20                                            LL 01440
```

```
C                                                                       LL 01480
C        INPUT SPECTRAL DATA FOR OZONE                                  LL 01490
C                                                                       LL 01500
      DO 6 J=1,540,10                                                   LL 01510
      K=J+9                                                             LL 01520
   50 FORMAT(8X,10(1X,F5.2))                                            LL 01530
    6 READ(5,50) (C3(I),I=J,K)                                          LL 01540
C                                                                       LL 01550
CC    WRITE(6,69)                                                       LL 01560
   69 FORMAT(8X,/,1X,'SPECTRAL DATA OZONE',/)                           LL 01570
CC    WRITE(6,51)                                                       LL 01580
   51 FORMAT(7X,/,1X,'C301 DATA ',/)                                    LL 01590
CC    WRITE(6,50) (C3(I),I=1,190)                                       LL 01600
C                                                                       LL 01610
CC    WRITE(6,52)                                                       LL 01620
   52 FORMAT(7X,/,1X,'C302 DATA ',/)                                    LL 01630
CC    WRITE(6,50) (C3(I),I=191,380)                                     LL 01640
C                                                                       LL 01650
CC    WRITE(6,53)                                                       LL 01660
   53 FORMAT(7X,/,1X,'C303 DATA ',/)                                    LL 01670
CC    WRITE(6,50) (C3(I),I=381,540)                                     LL 01680
C                                                                       LL 01700
C  **** INPUT SPECTRAL DATA FOR N2 CONTINUIUM                           LL 01710
        READ(5,72) (C4(I),I=1,5)                                        LL 01730
   72 FORMAT(8X,5(1X,1PE8.2))                                           LL 01740
C                                                                       LL 01750
      L=0                                                               LL 01760
      DO 7 J=1,18                                                       LL 01770
      L=L+6                                                             LL 01780
      M=L+6                                                             LL 01790
      READ(5,55) (C4(I),I=L,M)                                          LL 01800
   55 FORMAT(8X,7(1X,E8.2))                                             LL 01810
      L=L+1                                                             LL 01820
    7 CONTINUE                                                          LL 01830
C                                                                       LL 01840
      READ(5,73) (C4(I),I=132,133)                                      LL 01850
   73 FORMAT(8X,2(1X,1PE8.2))                                           LL 01860
C                                                                       LL 01870
CC    WRITE(6,54)                                                       LL 01880
   54 FORMAT(7X,/,1X,'C4 SPECTRAL DATA- N2 CONTINUIUM',/)               LL 01890
CC    WRITE(6,72) (C4(I),I=1,5)                                         LL 01900
CC    WRITE(6,14) (C4(I),I=6,131)                                       LL 01910
   14 FORMAT(1X,7(1X,1PE8.2))                                           LL 01920
CC    WRITE(6,73) (C4(I),I=132,133)                                     LL 01930
C                                                                       LL 01940
C                                                                       LL 01950
C *** SPECTRAL DATA'  H2O CONTINUUM (4 MICRON REGION DATA)              LL 01960
```

```
C                                                                       LL 01970
C       NOTE - IN LOWTRAN 3, THE H2O CONTINUUM DATA WAS FOR THE         LL 01980
C            10 MICRON REGION.  IN LOWTRAN 3B, THIS DATA IS REPLACED    LL 01990
C            BY AN EMPIRICAL EQUATION.                                  LL 02000
C                                                                       LL 02010
C                                                                       LL 02020
      READ(5,56)  (C5(I),I=1,15)                                        LL 02030
   56 FORMAT(1X,F5.3)                                                   LL 02040
CC    WRITE(6,57)                                                       LL 02050
   57 FORMAT(7X,/,1X,'SPECTRAL DATA H2O CONTINUM (4 MICRON REGION',/)   LL 02060
CC    WRITE(6,56) (C5(I),I=1,15)                                        LL 02070
C                                                                       LL 02090
C   INPUT AVERAGE CONTINENTAL AEROSOL MODEL.  DATA IS INPUTED 4 GROUPS  LL 02100
C      OF 45 EACH TO ALLOW  IDENTIFICATION OF SPECIFIC BLOCKS OF DATA.  LL 02110
C                                                                       LL 02120
C   CONTINENTAL AEROSOL MODEL                                           LL 02130
C                                                                       LL 02140
      DO 58 J=1,42,7                                                    LL 02150
      K=J+6                                                             LL 02160
   59 FORMAT(8X,7(1X,F7.5))                                             LL 02170
      READ(5,59)  (C701(I), I=J,K)                                      LL 02180
   58 CONTINUE                                                          LL 02190
      READ(5,62)  (C701(I),I=43,45)                                     LL 02200
   62 FORMAT(8X,3(1X,F7.5))                                             LL 02210
C                                                                       LL 02220
CC    WRITE(6,60)                                                       LL 02230
   60 FORMAT(8X,//,1X,'SPECTRAL DATA AEROSOL EXTINCTION                 LL 02240
     *  AVG CONTINENTAL AEROSOL MODEL',/)                               LL 02250
CC    WRITE(6,61) (C701(J),J=1,45)                                      LL 02260
   61 FORMAT(1X,7(1X,F7.5))                                             LL 02270
C                                                                       LL 02280
C   INPUT RURAL AEROSOL MODEL                                           LL 02290
C                                                                       LL 02300
      DO 63 J=1,42,7                                                    LL 02310
      K=J+6                                                             LL 02320
   63 READ(5,59)  (C702(I),I=J,K)                                       LL 02330
      READ(5,62)  (C702(I),I=43,45)                                     LL 02340
C                                                                       LL 02350
CC    WRITE(6,64)                                                       LL 02360
   64 FORMAT(8X,/,1X,'RURAL AEROSOL MODEL',/)                           LL 02370
CC    WRITE(6,61) (C702(J),J=1,45)                                      LL 02380
C                                                                       LL 02390
C *** URBAN AEROSOL MODEL                                               LL 02400
C                                                                       LL 02410
      DO 65 J=1,42,7                                                    LL 02420
      K=J+6                                                             LL 02430
   65 READ(5,59)  (C703(I),I=J,K)                                       LL 02440
```

```
      READ(5,62)  (C703(I),I=43,45)                                     LL 02450
C                                                                       LL 02460
CC    WRITE(6,66)                                                       LL 02470
   66 FORMAT(8X,/,1X,'URBAN AEROSOL MODEL',/)                           LL 02480
CC    WRITE(6,61)  (C703(I),I=1,45)                                     LL 02490
C                                                                       LL 02500
C *** MARITIME AEROSCI MODEL                                            LL 02510
C                                                                       LL 02520
      DO 67 J=1,42,7                                                    LL 02530
      K=J+6                                                             LL 02540
   67 READ(5,59)  (C704(I),I=J,K)                                       LL 02550
      READ(5,62)  (C704(I),I=43,45)                                     LL 02560
C                                                                       LL 02570
CC    WRITE(6,68)                                                       LL 02580
   68 FORMAT(8X,/,1X,'MARITIME AEROSOL MODEL',/)                        LL 02590
CC    WRITE(6,61)  (C704(I),  I=1,45)                                   LL 02600
C                                                                       LL 02630
C *** SPECTRAL DATA'  AEROSOL ABSORPTION                                LL 02640
C                                                                       LL 02650
C *** AVERAGE CONTINENTAL AEROSOL MODEL                                 LL 02660
C                                                                       LL 02680
      DO 16 J=1,42,7                                                    LL 02690
      K=J+6                                                             LL 02700
   16 READ(5,59)  (C7A01(I),I=J,K)                                      LL 02710
      READ(5,62)  (C7A01(I),I=43,45)                                    LL 02720
CC    WRITE(6,17)                                                       LL 02730
   17 FORMAT(8X,/,1X,'SPECTRAL DATA AEROSOL ABSORBTION  *** AVERAGE     LL 02740
     *CONTINENTAL AEROSOL MODEL',/)                                     LL 02750
CC    WRITE(6,61)  (C7A01(I),I=1,45)                                    LL 02760
C                                                                       LL 02770
C *** RURAL AEROSOL MODEL                                               LL 02780
C                                                                       LL 02790
      DO 70 J=1,42,7                                                    LL 02800
      K=J+6                                                             LL 02810
   70 READ(5,59)  (C7A02(I),I=J,K)                                      LL 02820
      READ(5,62)  (C7A02(I),I=43,45)                                    LL 02830
CC    WRITE(6,71)                                                       LL 02840
   71 FORMAT(8X,/,1X,'RURAL AEROSOL MODEL',/)                           LL 02850
CC    WRITE(6,61)  (C7A02(I),I=1,45)                                    LL 02860
C                                                                       LL 02870
C *** URBAN AEROSOL MODEL                                               LL 02880
C                                                                       LL 02890
      DO 74 J=1,42,7                                                    LL 02900
      K=J+6                                                             LL 02910
   74 READ(5,59)  (C7A03(I),I=J,K)                                      LL 02920
      READ(5,62)  (C7A03(I),I=43,45)                                    LL 02930
CC    WRITE(6,75)                                                       LL 02940
```

```
   75 FORMAT(8X,/,1X,'URBAN AEROSOL MODEL ',/)                          LL 02950
CC    WRITE(6,61) (C7A03(I),I=1,45)                                     LL 02960
C                                                                       LL 02970
C *** MARITIME AEROSOL MODEL                                            LL 02980
C                                                                       LL 02990
      DO 76 J=1,42,7                                                    LL 03000
      K=J+6                                                             LL 03010
   76 READ(5,59) (C7A04(I),I=J,K)                                       LL 03020
      READ(5,62) (C7A04(I),I=43,45)                                     LL 03030
CC    WRITE(6,77)                                                       LL 03040
   77 FORMAT(8X,/,1X,'MARATIME AEROSOL MODEL',/)                        LL 03050
CC    WRITE(6,61) (C7A04(I),I=1,45)                                     LL 03060
C                                                                       LL 03070
C *** SPECTRAL DATA'  OZONE - UV AND VISIBLE                            LL 03100
C                                                                       LL 03110
      READ(5,72) (C8(I),I=1,5)                                          LL 03120
      L=0                                                               LL 03130
      DO 78 J=1,13                                                      LL 03140
      L=L+6                                                             LL 03150
      M=L+6                                                             LL 03160
      READ(5,55) (C8(I),I=L,M)                                          LL 03170
      L=L+1                                                             LL 03180
   78 CONTINUE                                                          LL 03190
      READ(5,79) (C8(I),I=97,102)                                       LL 03200
   79 FORMAT(8X,6(1X,E8.2))                                             LL 03210
C                                                                       LL 03220
CC    WRITE(6,80)                                                       LL 03230
   80 FORMAT(8X,/,1X,'SPECTRAL DATA-- OZONE - UV AND VISIBLE',/)        LL 03240
CC    WRITE(6,72) (C8(I),I=1,5)                                         LL 03250
CC    WRITE(6,14) (C8(I),I=6,102)                                       LL 03260
C                                                                       LL 03280
C *** INPUT PARTIAL AMT OF C2 DATA                                      LL 03290
C                                                                       LL 03310
      DO 83 J=951,1570,10                                               LL 03320
      K=J+9                                                             LL 03330
   83 READ(5,50) (C2(I),I=J,K)                                          LL 03340
      READ(5,50) (C2(I),I=1571,1575)                                    LL 03350
C                                                                       LL 03360
CC    WRITE(6,84)                                                       LL 03370
   84 FORMAT(8X,/,1X,'SPECTRAL DATA*** UNIFORMLY MIXED GASES C206 DATA',LL 03380
     */)                                                                LL 03390
CC    WRITE(6,50) (C2(I),I=951,1140)                                    LL 03400
C                                                                       LL 03410
CC    WRITE(6,85)                                                       LL 03420
   85 FORMAT(8X,/,1X,'C207 DATA',/)                                     LL 03430
CC    WRITE(6,50) (C2(I),I=1141,1330)                                   LL 03440
CC    WRITE(6,81)                                                       LL 03450
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   81 FORMAT(8X,/,1X,'C208 DATA',/)                                     LL 03460
CC    WRITE(6,50) (C2(I),I=1331,1520)                                   LL 03470
C                                                                       LL 03480
CC    WRITE(6,82)                                                       LL 03490
   82 FORMAT(8X,/,1X,'C209 DATA',/)                                     LL 03500
CC    WRITE(6,50) (C2(I),I=1521,1575)                                   LL 03510
C                                                                       LL 03520
C  BEGIN MAIN CODE                                                      LL 03550
C*********************************************************************LL 03650
      CALL ARRAY (P,T,WH,WO,VX,C1,C2,C7,C7A)                            LL 01470
      IXY=2                                                             LL 03670
      IP=1                                                              LL 03680
      NL1=NL-1                                                          LL 03690
      DO 208 ITER=1,10000                                               LL 03700
         IF (IXY.LE.0.OR.IXY.GE.5) GO TO 209                            LL 03710
         IF (IXY.EQ.1) GO TO 107                                        LL 03720
         IF (IXY.EQ.3) GO TO 105                                        LL 03730
C                                                                       LL 03740
         READ(5,400) MODEL,IAERO,IHAZE,JP,IM,M1,M2,M3,ML,RO,VIS         LL 03750
         IF (MODEL.EQ.1) WRITE(6,410)                                   LL 03760
         IF (MODEL.EQ.2) WRITE(6,411)                                   LL 03770
         IF (MODEL.EQ.3) WRITE(6,412)                                   LL 03780
         IF (MODEL.EQ.4) WRITE(6,413)                                   LL 03790
         IF (MODEL.EQ.5) WRITE(6,414)                                   LL 03800
         IF (MODEL.EQ.6) WRITE(6,415)                                   LL 03810
         IF (M1.NE.0) WRITE(6,444) M1                                   LL 03820
         IF (M2.NE.0) WRITE(6,445) M2                                   LL 03830
         IF (M3.NE.0) WRITE(6,446) M3                                   LL 03840
         IF (IAERO.EQ.1) WRITE(6,447)                                   LL 03850
         IF (IAERO.EQ.2) WRITE(6,448)                                   LL 03860
         IF (IAERO.EQ.3) WRITE(6,449)                                   LL 03870
         IF (IAERO.EQ.4) WRITE(6,450)                                   LL 03880
         IF (IHAZE.EQ.0) WRITE(6,426)                                   LL 03890
         IF (IHAZE.EQ.1.AND.CKZERO(VIS)) VIS=23.                        LL 03900
         IF (IHAZE.EQ.2.AND.CKZERO(VIS)) VIS=5.                         LL 03910
         IF (.NOT.CKZERO(VIS)) WRITE(6,417) VIS                         LL 03920
         IF (VIS.GT.0.0.AND.VIS.LT.2.0) WRITE(6,442)                    LL 03930
         IF (MODEL.EQ.0) M=7                                            LL 03940
         IF (MODEL.NE.0) M=MODEL                                        LL 03950
         IF (MODEL.EQ.0) NLP=1                                          LL 03960
         IF (MODEL.NE.0.AND.MODEL.NE.7) NLP=NL                          LL 03970
         IF (MODEL.EQ.7) NLP=MAX0(ML,1)                                 LL 03980
            IF (ML.GT.NL) WRITE(6,451) ML,NL                            LL 03990
            IF (ML.GT.NL) STOP                                          LL 04000
C                                                                       LL 04010
         DO 101 I = 1,NL                                                LL 04020
            IF (M.NE.7) AHZ1(I)=HZ1(I)                                  LL 04030
```

```
            IF (M.NE.7) AHZ2(I)=HZ2(I)                                  LL 04040
            IF (M.NE.7) Z(I)=Z0(I)                                      LL 04050
 101        CONTINUE                                                    LL 04060
         IF (      CKZERO(R0)) RE=REARTH(M)                             LL 04070
         IF (.NOT.CKZERO(R0)) RE=R0                                     LL 04080
         IF (M.NE.7.OR.IM.EQ.0) GO TO 104                               LL 04090
C                                                                       LL 04100
C**** READ IN RADIOSCNDE (MODEL = 7) OR METEOROLOGICAL (MODEL = 0) DATA LL 04110
C                                                                       LL 04120
 100     CONTINUE
          DO 103 K = 1,NLP                                              LL 04130
            IF (MODEL.EQ.0) READ(5,429) Z(K),P(7,K),TMP,DP,RH,WH(7,K),  LL 04140
     *        WO(7,K),RANGE                                             LL 04150
            IF (MODEL.EQ.7) READ(5,429) Z(K),P(7,K),TMP,DP,RH,WH(7,K),  LL 04160
     *          WO(7,K),AHZ1(K)                                         LL 04170
            IF (MODEL.EQ.0) AHZ1(K)=0.0                                 LL 04180
            IF (MODEL.EQ.0) H1=Z(K)                                     LL 04190
            DO 102 I = 1,NL1                                            LL 04200
 102          IF (Z(K).GE.Z0(I)) J=I                                   LL 04210
            FAC=(Z(K)-Z0(J))/(Z0(J+1)-Z0(J))                            LL 04220
            T(7,K)=TMP+273.15                                           LL 04230
            IF (M1.NE.0) T(7,K)=T(M1,J)*(T(M1,J+1)/T(M1,J))**FAC        LL 04240
            IF (.NOT.CKZERO(RH)) TT=273.15/T(7,K)                       LL 04250
            IF (.NOT.CKZERO(DP)) TT=273.15/(273.15+DP)                  LL 04260
            IF (CKZERO(WH(7,K))) WH(7,K)=EXP(18.9766-14.9595*TT-2.43882 LL 04270
     *          *TT**2)*TT                                              LL 04280
            IF (.NOT.CKZERO(RH)) WH(7,K)=0.01*RH*WH(7,K)                LL 04290
            IF (M2.NE.0) WH(7,K)=WH(M2,J)*(WH(M2,J+1)/WH(M2,J))**FAC    LL 04300
            IF (M3.NE.0) WO(7,K)=WO(M3,J)*(WO(M3,J+1)/WO(M3,J))**FAC    LL 04310
            IF (CKZERO(AHZ1(K))) AHZ2(K)=HZ2(J)*(HZ2(J+1)/HZ2(J))**FAC  LL 04320
            IF (.NOT.CKZERO(AHZ1(K))) AHZ2(K)=AHZ1(K)                   LL 04330
            IF (CKZERO(AHZ1(K))) AHZ1(K)=HZ1(J)*(HZ1(J+1)/HZ1(J))**FAC  LL 04340
            IF (MODEL.EQ.0) WRITE(6,430) Z(K),P(7,K),TMP,DP,RH,WH(7,K), LL 04350
     *          WO(7,K),RANGE                                           LL 04360
            IF (MODEL.EQ.7) WRITE(6,429) Z(K),P(7,K),TMP,DP,RH,WH(7,K), LL 04370
     *          WO(7,K),AHZ1(K)                                         LL 04380
 103        CONTINUE                                                    LL 04390
C                                                                       LL 04400
 104     CONTINUE                                                       LL 04410
         IF (M1.EQ.0) M1=M                                              LL 04420
         IF (M2.EQ.0) M2=M                                              LL 04430
         IF (M3.EQ.0) M3=M                                              LL 04440
         IF (MODEL.EQ.0) ITYPE=1                                        LL 04450
         IF (MODEL.EQ.0) GO TO 107                                      LL 04460
         IF (IXY.EQ.4) GO TO 108                                        LL 04470
C                                                                       LL 04480
 105     CONTINUE                                                       LL 04490
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C         IF(MODEL.EQ.0) GO TO 100
          READ(5,406) ITYPE,LEN,H1,H2,ANGLE,RANGE,BETA                  LL 04500
          X1=RE+H1                                                      LL 04510
          IFIND=0                                                       LL 04520
          IF (CKZERO(RANGE).AND.((ITYPE.EQ.2.AND..NOT.CKZERO(BETA))     LL 04530
     *        .OR.(ITYPE.EQ.3.AND.H2.LT.H1.AND.H2.GT.0.0))) IFIND=1     LL 04540
          IF (ITYPE.EQ.1.OR.ITYPE.EQ.3) GO TO 106                       LL 04550
          ITYPE=2                                                       LL 04560
          IF (.NOT.CKZERO(ANGLE).AND..NOT.CKZERO(BETA)) H2=             LL 04570
     *       X1*ABS((SIN(ANGLE*CA)/SIN((ANGLE-BETA)*CA)))-RE            LL 04580
          IF (.NOT.CKZERO(ANGLE).AND..NOT.CKZERO(RANGE)) H2=            LL 04590
     *       X1*SQRT(1.+(RANGE/X1)**2+2.*(RANGE/X1)*COS(ANGLE*CA))-RE   LL 04600
          IF (.NOT.CKZERO(BETA).AND..NOT.CKZERO(RANGE)) H2=             LL 04610
     *       X1*ABS(COS(BETA*CA)+SQRT((RANGE/X1)**2-SIN(BETA*CA)**2))-RE LL 04620
          X2=RE+H2                                                      LL 04630
          IF (.NOT.CKZERO(RANGE)) ANGLE=ARCOS(((X2/X1)*(X2/RANGE)-      LL 04640
     *       (X1/RANGE)-(RANGE/X1))/2.)/CA                              LL 04650
          IF (.NOT.CKZERO(BETA*CA)) ANGLE=ATAN(X2*SIN(BETA*CA)/(X2*     LL 04660
     *       COS(BETA*CA)-X1))/CA                                       LL 04670
          IF (ANGLE.LT.0.0) ANGLE=ANGLE+180.                            LL 04680
          IF (CKZERO(RANGE)) RANGE=X1*ABS(SQRT((X2/X1)**2-SIN(ANGLE*CA) LL 04690
     *       **2)-COS(ANGLE*CA))                                        LL 04700
          IF (CKZERO(BETA)) BETA=ARSIN((RANGE/X2)*SIN(ANGLE*CA))/CA     LL 04710
  106     CONTINUE                                                      LL 04720
          WRITE(6,428) H1,H2,ANGLE,RANGE,BETA                           LL 04730
          IF (ITYPE.EQ.1) WRITE(6,407) H1,RANGE                         LL 04740
          IF (ITYPE.EQ.2) WRITE(6,408) H1,H2,ANGLE                      LL 04750
          IF (ITYPE.EQ.3) WRITE(6,409) H1,ANGLE                         LL 04760
          IF (ITYPE.EQ.3) H2=Z(NLP)                                     LL 04770
C                                                                       LL 04780
  107     CONTINUE                                                      LL 04790
          IF (IXY.EQ.3.OR.IXY.EQ.4) GO TO 108                           LL 04800
          READ(5,405) V1,V2,DV                                          LL 04810
          WL2=10000./V1                                                 LL 04820
          WL1=10000./V2                                                 LL 04830
          IF (IXY.LE.2) WRITE(6,418) V1,V2,DV,WL1,WL2                   LL 04840
          WL=SQRT(WL1*WL2)                                              LL 04850
          CO=77.46 +0.459/WL**2                                         LL 04860
          CW=43.487-0.3473/WL**2                                        LL 04870
          IF (IXY.EQ.1) GO TO 49                                        LL 04880
C                                                                       LL 04890
  108     CONTINUE                                                      LL 04900
          IF (IFIND.EQ.1) CALL ANGL (H1,H2,ANGLE,BETA,LEN,NLP)          LL 04910
          IF (IFIND.EQ.1) GO TO 110                                     LL 04920
          IF (JP.EQ.0) WRITE(6,427)                                     LL 04930
          IF (ITYPE.EQ.1) GO TO 1100                                    LL 04940
          DO 109 K = 1,10                                               LL 04950
```

```
 109        VH(K)=0.0
          EETA=0.0
          SR=0.0
C
C**** NOW DEFINE CONSTANT PRESSURE PATH QUANTITIES EH(1-8)
C
          SPHI=SIN(ANGLE*CA)
          R1=(RE+H1)*SPHI
          IF (H1.LE.Z(NLP)) GO TO 110
          X=(RE+Z(NLP))/(RE+H1)
          IF (SPHI.GT.X) HMIN=R1-RE
          IF (SPHI.GT.X) WRITE(6,433) HMIN
          IF (SPHI.GT.X) GO TO 209
          H1=Z(NLP)
          J1=NLP
          SPHI=SPHI/X
          ANGLE=180.-ARSIN(SPHI)/CA
 110      CONTINUE
          R1=(RE+H1)*SPHI
1100      CONTINUE
          DO 112 I = 1,NLP
             PS=P(M,I)/1013.0
             TS=273.15/T(M1,I)
             TS1=(296.0/273.15)*TS
             X=PS*TS
             PT=PS*SQRT(TS)
             D=0.1*WH(M2,I)
             PPW=4.56E-6*T(M1,I)*WH(M2,I)
C
C    ***   THIS DEFINITION OF HAZE WHEN VIS = 0.0 MAY BE IN ERROR.
C
             IF (CKZERO(VIS)) HAZE=0.0
             IF (.NOT.CKZERO(VIS)) HAZE=115.*((AHZ2(I)-AHZ1(I))/VIS+
     *          AHZ1(I)/5.0-AHZ2(I)/23.0)/18.
             EH(1,I)=D*PT**0.9
             EH(2,I)=X*PT**0.75
             EH(3,I)=46.667*WO(M3,I)*PT**0.4
             EH(4,I)=0.8*PT*X
             EH(5,I)=D*(PPW*EXP(6.08*(TS1-1.0))+0.002*(PS-PPW))
             EH(6,I)=X
             EH(7,I)=3.5336E-4*AMAX1(HAZE,0.0)
             EH(8,I)=46.667*WO(M3,I)
             EH(9,I)=0.0
             EH(10,I)=D*(0.12*PS+0.88*PPW)*EXP(4.56*(TS1-1.0))
             REF=CO*P(M,I)/T(M1,I)-4.56E-6*CW*WH(M2,I)*T(M1,I)
             IF (I.EQ.NLP) GO TO 111
             PPW=4.56E-6*T(M1,I+1)*WH(M2,I+1)
```

```
            EH(9,I)=0.5E-6*(REF+CO*P(M,I+1)/T(M1,I+1)-PPW*CW)
            IF (IFIND.EQ.0.OR.JP.EQ.0) WRITE(6,434) I,Z(I),
     *         (EH(K,I),K=1,10),REF
 111        CONTINUE
            IF (H1.GE.Z(I)) J1=I
            EH(9,I)=EH(9,I)+1.0
 112        CONTINUE
         IF (MODEL.NE.0) CALL POINT (H1,YN1,J1,NP1,E,IP)
         TX1=E(9)
         IF (ITYPE.EQ.1) GO TO 47
C
C**** DOWNWARD TRAJECTORY
C
         IF (ANGLE.LE.90.) GO TO 19
         K2=0
         IF (NP1.EQ.1) J1=J1-1
         J2=J1+1
         JP1=J1+1
         IF ((H2.GT.Z(J1+1).OR.CKZERO(H2-H1)).OR.(NP1.EQ.1.AND.
     *      H2.GE.Z(J1+1))) GO TO 30
         CALL POINT (H2,YN2,J2,NP2,W,IP)
         TX2=W(9)
         IF (H2.LT.H1) H=H2
         IF (J1.EQ.J2) TX2=TX1+YN2-EH(9,N)
         IF (H2.GT.H1) TX1=TX2
         IF (J1.EQ.J2.AND.H2.LT.H1) YN1=TX2
  30     A0=(RE+H1)*SPHI*YN1
         IF (H2.GE.H1) YN2=YN1
         DO 31 I = 1,J1
            IF (I.NE.J1) HMIN=A0/EH(9,I)-RE
            IF (I.EQ.J1) HMIN=A0/YN1-RE
            IF (HMIN.LE.Z(I+1)) GO TO 32
  31        CONTINUE
  32     X=HMIN
         IF (HMIN.LE.0.00) GO TO 34
C
C   ***   THE USE OF YN BELOW MAY POSSIBLY BE IN ERROR
C            SHOULD BE YN1 OR YN2
C
         CALL POINT (HMIN,YN,JMIN,NP,TX,IP)
         TX3=TX(9)
         IF (J2.EQ.JMIN.OR.J1.EQ.JMIN) TX3=YN2+TX(9)-EH(9,N)
         IF (J1.EQ.JMIN.AND.H2.GE.H1) GO TO 33
         HMIN=A0/TX3-RE
         IF (ABS(X-HMIN).GT.0.0001) GO TO 32
  33     IF (J1.EQ.JMIN.AND.H2.GE.H1) YN1=TX3
         IF (J2.EQ.JMIN.AND.J1.NE.J2) YN2=TX3
```

```
      IF (H2.GE.H1) TX2=TX3                                             LL 05900
      IF (H2.GE.H1) J2=JMIN                                             LL 05910
      IF (H2.GE.H1.OR.H2.LT.HMIN) H=HMIN                                LL 05920
      WRITE(6,436) HMIN                                                 LL 05930
      IF (H2.LT.HMIN) WRITE(6,440) HMIN                                 LL 05940
      GO TO 35                                                          LL 05950
C                                                                       LL 05960
   34 WRITE(6,436) HMIN                                                 LL 05970
      IF (H2.LT.H1) GO TO 35                                            LL 05980
      IF (ITYPE.EQ.3.OR.H2.GE.H1) WRITE(6,437)                          LL 05990
      ITYPE=2                                                           LL 06000
      TX2=EH(9,1)                                                       LL 06010
      JMIN=0                                                            LL 06020
      J2=1                                                              LL 06030
      H2=0.0                                                            LL 06040
      H=0.0                                                             LL 06050
C                                                                       LL 06060
C**** NOW DEFINE VERTICAL PATH QUANTITIES VH(1-8)                       LL 06070
C                                                                       LL 06080
   35 IF (JP.EQ.0) WRITE(6,420)                                         LL 06090
      DO 135 ITES = 1,10000                                             LL 06100
         IF (K2.EQ.0) REF=YN1                                           LL 06110
         IF (K2.EQ.1) REF=YN2                                           LL 06120
         X1=H1                                                          LL 06130
         J=JP1+1                                                        LL 06140
   38    CONTINUE                                                       LL 06150
         J=J-1                                                          LL 06160
         X2=Z(J)                                                        LL 06170
         IF (J.EQ.J2.AND.K2.EQ.0) X2=H                                  LL 06180
         IF (J.EQ.JMIN.AND.K2.EQ.1) X2=HMIN                             LL 06190
         HM=(RE+X1)*SPHI-RE                                             LL 06200
         IF (HM.GT.Z(J).AND.HM.GT.X2) X2=HM                             LL 06210
         RX=(RE+X1)/(RE+X2)                                             LL 06220
         DS=X1-X2                                                       LL 06230
         ALP=90.0                                                       LL 06240
         THET=ARSIN(SPHI)/CA                                            LL 06250
         SALP=RX*SPHI                                                   LL 06260
         IF (ABS(X2-HM).GT.1.E-5) ALP=ARSIN(SALP)/CA                    LL 06270
         BET=ALP-THET                                                   LL 06280
         IF (SPHI.GT.1.E-10) DS=(RE+X2)*SIN(BET*CA)/SPHI                LL 06290
         THETA=180.-THET                                                LL 06300
         BETA=BETA+BET                                                  LL 06310
         PSI=BETA-ALP-ANGLE+180.                                        LL 06320
         SR=SR+DS                                                       LL 06330
         DO 39 K = 1,10                                                 LL 06340
            AJ=EH(K,J)                                                  LL 06350
            BJ=EH(K,J+1)                                                LL 06360
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            IF (J.EQ.J1) BJ=E(K)                                        LL 06370
            IF (J.EQ.J2.AND.H2.LT.H1.AND.H2.GT.0.0) AJ=W(K)             LL 06380
            IF (J.EQ.JMIN.AND.H2.GE.H1) AJ=TX(K)                        LL 06390
            IF (J.EQ.JMIN.AND.ABS(H2-HM).LT.1.E-5) AJ=TX(K)             LL 06400
            IF (K2.NE.0.AND.J.EQ.J2) BJ=W(K)                            LL 06410
            IF (K2.NE.0.AND.J.EQ.JMIN) AJ=TX(K)                         LL 06420
            IF (CKZERO(AJ).OR.CKZERO(BJ)) EV=0.0                        LL 06430
            IF (CKZERO(AJ-BJ)) EV=DS*AJ                                 LL 06440
            IF (.NOT.CKZERO(AJ).AND..NOT.CKZERO(BJ).AND.                LL 06450
     *         .NOT.CKZERO(AJ-BJ)) EV=DS*(AJ-BJ)/ALOG(AJ/BJ)            LL 06460
            VH(K)=VH(K)+EV                                              LL 06470
 39         CONTINUE                                                    LL 06480
          IF (JP.EQ.0) WRITE(6,435) J,X1,(VH(L),L=1,8),PSI,ALP,         LL 06490
     *       BETA,THETA,SR                                              LL 06500
          IF (J.EQ.J2.AND.H2.GE.H1) GO TO 45                            LL 06510
          IF (J.EQ.JMIN.AND.K2.EQ.1) GO TO 43                           LL 06520
          IF (J.NE.1) RN=REF/EH(9,J-1)                                  LL 06530
          IF (J.EQ.J2+1) RN=REF/TX2                                     LL 06540
          IF (J.EQ.J2.AND.K2.EQ.0) RN=REF/YN2                           LL 06550
          IF (J.EQ.(JMIN+1).AND.K2.EQ.1) RN=REF/TX3                     LL 06560
          IF (SALP.GE.RN) RN=1.0                                        LL 06570
          SPHI=SALP*RN                                                  LL 06580
          REF=EH(9,J)                                                   LL 06590
          IF (J.EQ.J2+1.AND.K2.EQ.0) REF=TX2                            LL 06600
          X1=X2                                                         LL 06610
          IF (J.NE.1.AND.(J.NE.J2.OR.K2.NE.0)) GO TO 38                 LL 06620
          IF (HMIN.LE.0.0) GO TO 47                                     LL 06630
          IF (LEN.EQ.0) WRITE(6,438)                                    LL 06640
          IF (LEN.EQ.0) GO TO 47                                        LL 06650
          WRITE(6,439)                                                  LL 06660
          K2=1                                                          LL 06670
          IF (ABS(X1-HMIN).LE.0.001) GO TO 47                           LL 06680
          H=HMIN                                                        LL 06690
          JP1=J2+1                                                      LL 06700
          IF (NP2.EQ.1) JP1=JP1-1                                       LL 06710
          B=BETA                                                        LL 06720
          PH=180.-ARSIN(SPHI)/CA                                        LL 06730
          TS=SR                                                         LL 06740
          PS=PSI                                                        LL 06750
          DO 42 K = 1,10                                                LL 06760
 42          E(K)=VH(K)                                                 LL 06770
135       CONTINUE                                                      LL 06780
 43     BETA=2.*BETA-B                                                  LL 06790
        PSI=2.*PSI-PS                                                   LL 06800
        SR=2.*SR-TS                                                     LL 06810
C                                                                       LL 06820
C****  LONG PATH  TAKEN                                                 LL 06830
```

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C
      PHI=PH
      DO 44 K = 1,10
44       VH(K)=2.*VH(K)-E(K)
      GO TO 47
C
45    CONTINUE
      DO 46 K = 1,10
46       VH(K)=2.0*VH(K)
      BETA=2.0*BETA
      SR=2.0*SR
      IF (CKZERO(H2-H1)) GO TO 47
      RN=TX1/YN1
      SPHI=SIN(ANGLE*CA)
      IF (SPHI.LT.FN) SPHI=SPHI/RN
C
C****  UPWARD TRAJECTORY
C
19    IF (ANGLE.GT.90..AND.NP1.GT.0) J1=J1+1
      IF (ITYPE.EQ.3) J2=NLP
      IF (ITYPE.EQ.2) CALL POINT(H2,YN2,J2,NP,TX,IP)
      IF (ITYPE.EQ.2.AND.NP.EQ.1) J2=J2-1
      EH(10,J1)=E(10)
      DO 21 K = 1,8
         IF (ITYPE.EQ.3) EH(K,J1)=E(K)
         IF (ITYPE.EQ.2) EH(K,J2+1)=TX(K)
21       CONTINUE
      IF (ITYPE.EQ.2) EH(10,J2+1)=TX(10)
      IF (J1.EQ.J2) TX1=TX1+YN2-EH(9,J1)
C
C**** NOW DEFINE VERTICAL PATH QUANTITIES VH(1-8)
C
      IF (JP.EQ.0) WRITE(6,420)
      X1=H1
      DO 25 I = J1,J2
         X2=Z(I+1)
         IF (I.EQ.J2) X2=H2
         DZ=X2-X1
         IF (I.EQ.NLP) DZ=Z(I)-Z(I-1)
         RX=(RE+X1)/(RE+X2)
         THETA=ARSIN(SPHI)/CA
         PHI=ARSIN(SPHI*RX)/CA
         BET=THETA-PHI
         SALP=RX*SPHI
         IF (SPHI.GT.1.E-10) DZ=(RE+X2)*SIN(BET*CA)/SPHI
         BETA=BETA+BET
         PSI=BETA+PHI-ANGLE
```

```
      PHI=180.-PHI                                                      LL 07310
      SR=SR+DZ                                                          LL 07320
      IO=MAX0(MIN0(I,NLP-1),1)                                          LL 07330
      DO 24 K = 1,10                                                    LL 07340
         IF (CKZERO(EH(K,IO)).OR.CKZERO(EH(K,IO+1)).OR.                 LL 07350
     *      CKZERO(EH(K,IO)-EH(K,IO+1)))                                LL 07360
     *      EV=DZ*AMIN1(EH(K,IO),EH(K,IO+1))                            LL 07370
         IF (.NOT.CKZERO(EH(K,IO)).AND..NOT.CKZERO(EH(K,IO+1))          LL 07380
     *      .AND..NOT.CKZERO(EH(K,IO)-EH(K,IO+1)).AND.I.NE.NLP)         LL 07390
     *      EV=DZ*(EH(K,IO)-EH(K,IO+1))/ALOG(EH(K,IO)/                  LL 07400
     *      EH(K,IO+1))                                                 LL 07410
         IF (.NOT.CKZERO(EH(K,IO)).AND..NOT.CKZERO(EH(K,IO+1))          LL 07420
     *      .AND..NOT.CKZERO(EH(K,IO)-EH(K,IO+1)).AND.I.EQ.NLP)         LL 07430
     *      EV=DZ*EH(K,IO+1)/ALOG(EH(K,IO)/EH(K,IO+1))                  LL 07440
         VH(K)=VH(K)+EV                                                 LL 07450
24       CONTINUE                                                       LL 07460
      IF (JP.EQ.0) WRITE(6,435) I,X1,(VH(L),L=1,8),PSI,PHI,BETA,        LL 07470
     *   THETA,SR                                                       LL 07480
      IF (I.EQ.NLP) GO TO 25                                            LL 07490
      IF (I.EQ.J2-1) EH(9,I+1)=YN2                                      LL 07500
      IF (I.EQ.J1) EH(9,I)=TX1                                          LL 07510
      RN=EH(9,I+1)/EH(9,I)                                              LL 07520
      SPHI=SPHI*RX/RN                                                   LL 07530
      IF (SALP.GE.RN) SPHI=SALP                                         LL 07540
      X1=X2                                                             LL 07550
25    CONTINUE                                                          LL 07560
47 CONTINUE                                                             LL 07570
   IF (ITYPE.NE.1) WRITE(6,443) HM                                      LL 07580
   DO 48 K = 1,10                                                       LL 07590
      IF (ITYPE.EQ.1.AND.MODEL.NE.0) W(K)=RANGE*E(K)                    LL 07600
      IF (ITYPE.EQ.1.AND.MODEL.EQ.0) W(K)=RANGE*EH(K,1)                 LL 07610
      IF (ITYPE.NE.1) W(K)=VH(K)                                        LL 07620
48    CONTINUE                                                          LL 07630
49 WRITE(6,419)                                                         LL 07640
   WRITE(6,421) (W(I),I=1,8),W(10)                                      LL 07650
C                                                                       LL 07660
C**** BEGINNING OF TRANSMITTANCE CALCULATIONS                           LL 07670
C                                                                       LL 07680
   IV1=MAX0(5*IFIX(V1/5.0),350)                                         LL 07690
   IV2=MIN0(5*IFIX(V2/5.0+0.99),50000)                                  LL 07700
   DV=AMAX1(DV,5.0)                                                     LL 07710
   IDV=IFIX(DV)                                                         LL 07720
   SUM=0.0                                                              LL 07730
   DO 206 IV = IV1,IV2,IDV                                              LL 07740
      IF (IV.GE. 350.AND.IV.LT. 9875) I=(IV- 350)/5+ 1                  LL 07750
      IF (IV.GE. 9875.AND.IV.LT.12800) I=(IV- 9875)/5+ 1771             LL 07760
      IF (IV.GE.12800.AND.IV.LT.13400) I=(IV-12800)/5+ 2491             LL 07770
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      IF (IV.GE.13400.AND.IV.LE.14500) I=(IV-13400)/5+ 2356          LL 07780
      IF (IV.GT.14500.AND.IV.LE.50000) I=(IV-14500)/5+ 2831          LL 07790
      IF (IV.GE.  500.AND.IV.LT. 8060) J=(IV-  500)/5+    1          LL 07800
      IF (IV.GT.12970.AND.IV.LT.13190) J=(IV-12970)/5+ 1520          LL 07810
      K=(IV-575)/5+1                                                 LL 07820
      IF ((IV.GE.  350.AND.IV.LT.12800).OR.                          LL 07830
     *    (IV.GE.13400.AND.IV.LE.14500))                             LL 07840
     *   WS1=ALOG10(AMAX1(W(1),1.0E-20))+C1(I)                       LL 07850
      IF ((IV.LT.  350.OR. IV.GE.12800).AND.                         LL 07860
     *    (IV.LT.13400.OR. IV.GT.14500)) WS1=FW(1)-1.0               LL 07870
      IF ((IV.GE.  500.AND.IV.LT. 8060).OR.                          LL 07880
     *    (IV.GT.12970.AND.IV.LT.13190))                             LL 07890
     *   WS2=ALOG10(AMAX1(W(2),1.0E-20))+C2(J)                       LL 07900
      IF ((IV.LT.  500.OR. IV.GE. 8060).AND.                         LL 07910
     *    (IV.LE.12970.OR. IV.GE.13190)) WS2=FW(1)-1.0               LL 07920
      IF ( IV.GE.  575.AND.IV.LE. 3270)                              LL 07930
     *   WS3=ALOG10(AMAX1(W(3),1.0E-20))+C3(K)                       LL 07940
      IF ( IV.LT.575.OR. IV.GT. 3270) WS3=FO(1)-1.0                  LL 07950
      NS1=0                                                          LL 07960
      NS2=0                                                          LL 07970
      NS3=0                                                          LL 07980
      DO 202 L = 1,67                                                LL 07990
         IF (WS1.GE.FW(L)) NS1=L                                     LL 08000
         IF (WS2.GE.FW(L)) NS2=L                                     LL 08010
         IF (WS3.GE.FO(L)) NS3=L                                     LL 08020
 202     CONTINUE                                                    LL 08030
C                                                                    LL 08040
C******* WATER VAPOR                                                 LL 08050
C                                                                    LL 08060
      IF (NS1.EQ.0) TX(1)=1.0                                        LL 08070
      IF (NS1.GT.0.AND.NS1.LT.67) TX(1)=TR(NS1+1)+                   LL 08080
     *    (TR(NS1)-TR(NS1+1))*(FW(NS1+1)-WS1)/(FW(NS1+1)-FW(NS1))    LL 08090
      IF (NS1.EQ.67) TX(1)=0.0                                       LL 08100
C                                                                    LL 08110
C******* UNIFORMLY MIXED GASES                                       LL 08120
C                                                                    LL 08130
      IF (NS2.EQ.0) TX(2)=1.0                                        LL 08140
      IF (NS2.GT.0.AND.NS2.LT.67) TX(2)=TR(NS2+1)+                   LL 08150
     *    (TR(NS2)-TR(NS2+1))*(FW(NS2+1)-WS2)/(FW(NS2+1)-FW(NS2))    LL 08160
      IF (NS2.EQ.67) TX(2)=0.0                                       LL 08170
C                                                                    LL 08180
C******* OZONE                                                      LL 08190
C                                                                    LL 08200
      IF (NS3.EQ.0) TX(3)=1.0                                        LL 08210
      IF (NS3.GT.0.AND.NS3.LT.67) TX(3)=TR(NS3+1)+                   LL 08220
     *    (TR(NS3)-TR(NS3+1))*(FO(NS3+1)-WS3)/(FO(NS3+1)-FO(NS3))    LL 08230
      IF (NS3.EQ.67) TX(3)=0.0                                       LL 08240
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C                                                                       LL 08250
C******* NITROGEN CONTINUUM                                             LL 08260
            K=(IV- 2080)/5+     1                                       LL 08280
            IF (IV.LT.2080.OR.IV.GE.2740) TX(4)=0.0                     LL 08290
            IF (IV.GE. 2080.AND.IV.LT. 2740) TX(4)=C4(K)*W(4)           LL 08300
C                                                                       LL 08310
C******* WATER VAPOR CONTINUUM                                          LL 08320
            XI=FLOAT(IV-2350)/50.0                                      LL 08340
            NH=IFIX(XI)                                                 LL 08350
            TX(5)=0.0                                                   LL 08360
C                                                                       LL 08370
C*******      10 MICRON REGION                                          LL 08380
            IF (IV.GE.  670.AND.IV.LE. 1350) TX(5)=(4.18+5578.0*        LL 08400
     *         EXP(-7.87E-3*FLOAT(IV)))*W(5)                            LL 08410
C                                                                       LL 08420
C*******      4 MICRON REGION                                           LL 08430
            IF (IV.GE.2350.AND.IV.LE.3000) TX(5)=(C5(NH)+(XI-FLOAT(NH)) LL 08450
     *         *(C5(NH+1)-C5(NH)))*W(10)                                LL 08460
C                                                                       LL 08470
C******* MOLECULAR SCATTERING                                           LL 08480
            IF (IV.LT.2740) TX(6)=0.0                                   LL 08500
            IF (IV.GE. 2740.AND.IV.LE.50000)                            LL 08510
     *         TX(6)=9.807E-20*(FLOAT(IV)**4.0117)*W(6)                 LL 08520
C                                                                       LL 08530
C******* AEROSOL EXTINCTION                                             LL 08540
            WL=10000./FLOAT(IV)                                         LL 08560
            XX=0.0                                                      LL 08570
            YY=0.0                                                      LL 08580
            TX(7)=0.0                                                   LL 08590
            TX(10)=0.0                                                  LL 08600
            IF (IHAZE.EQ.0) GO TO 204                                   LL 08610
            NS=0                                                        LL 08620
            DO 203 L = 1,44                                             LL 08630
 203           IF (WL.GE.VX(IAERO,L)) NS=L                              LL 08640
            IF (NS.GT.0.AND.NS.LT.44) XX=C7 (IAERO,NS+1)+               LL 08650
     *         (C7 (IAERO,NS)-C7 (IAERO,NS+1))*(VX(IAERO,NS+1)-WL)/     LL 08660
     *         (VX(IAERO,NS+1)-VX(IAERO,NS))                            LL 08670
            IF (NS.GT.0.AND.NS.LT.44) YY=C7A(IAERO,NS+1)+               LL 08680
     *         (C7A(IAERO,NS)-C7A(IAERO,NS+1))*(VX(IAERO,NS+1)-WL)/     LL 08690
     *         (VX(IAERO,NS+1)-VX(IAERO,NS))                            LL 08700
 204        CONTINUE                                                    LL 08710
            TX(7)=XX*W(7)                                               LL 08720
            TX(10)=YY*W(7)                                              LL 08730
C                                                                       LL 08740
C******* UV OZONE                                                       LL 08750
            IF (IV.GE.13000.AND.IV.LE.23400) XI=FLOAT(IV-13000)/200.+ 1.LL 08770
            IF (IV.GE.27500.AND.IV.LE.50000) XI=FLOAT(IV-27500)/500.+57.LL 08780
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      N=IFIX(XI)+1                                                      LL 08790
      IF ((IV.GE.13000.AND.IV.LE.23400).OR.                             LL 08800
     *   (IV.GE.27500.AND.IV.LE.50000))                                 LL 08810
     *   TX(8)=W(8)*(C8(N)+(XI-FLOAT(N))*C8(N-1))                       LL 08820
      IF ((IV.LT.13000.OR.IV.GT.23400).AND.                             LL 08830
     *   (IV.LT.27500.OR.IV.GT.50000)) TX(8)=0.0                        LL 08840
C                                                                       LL 08850
      TX(9)=0.0                                                         LL 08860
      IF (IV.GE. 2080.AND.IV.LT. 2740) TX(9)=TX(9)+TX(4)                LL 08870
      IF (IV.GT.  670.AND.IV.LT. 3000) TX(9)=TX(9)+TX(5)                LL 08880
      IF (IV.GE. 2740.AND.IV.LT.50000) TX(9)=TX(9)+TX(6)                LL 08890
      TX(9)=TX(9)+TX(7)                                                 LL 08900
      IF ((IV.GE.13000.AND.IV.LE.23400).OR.                             LL 08910
     *   (IV.GE.27500.AND.IV.LE.50000)) TX(9)=TX(9)+TX(8)               LL 08920
      DO 205 L = 4,10                                                   LL 08930
205      TX(L)=EXP(-TX(L))                                              LL 08940
      TX(10)=1.0-TX(10)                                                 LL 08950
      TX(9)=TX(1)*TX(2)*TX(3)*TX(9)                                     LL 08960
      IF (IV.GE.13000.AND.IV.LE.50000) TX(3)=TX(8)                      LL 08970
      IF (JP.EQ.3) TX(9)=TX(7)                                          LL 08980
      AB=1.0-TX(9)                                                      LL 08990
      IF (IV.EQ.IV1.OR.IV.EQ.IV2) AB=0.5*AB                             LL 09000
      SUM=SUM+AB*FLOAT(IDV)                                             LL 09010
      IF (JP.EQ.0.AND.IABS(MOD(IV-IV1,50*IDV)).EQ.0) WRITE(6,422)       LL 09020
      IF (JP.EQ.0) WRITE(6,423) IV,WL,TX(9),(TX(L),L=1,7),TX(10),       LL 09030
     *   SUM                                                            LL 09040
206   CONTINUE                                                          LL 09050
    AB=1.-SUM/FLOAT(IV2-IV1)                                            LL 09060
    WRITE(6,424) IV1,IV2,SUM,AB                                         LL 09070
    READ(5,400) IXY                                                     LL 09080
208 CONTINUE                                                            LL 09090
209 CONTINUE                                                            LL 09100
    STOP                                                                LL 09110
C                                                                       LL 09120
400 FORMAT(9I3,3X,2F10.3)                                               LL 09130
405 FORMAT(3F10.3)                                                      LL 09140
406 FORMAT(2I3,4X,5F10.3)                                               LL 09150
407 FORMAT(/10X,29H HORIZONTAL PATH, ALTITUDE = ,F7.3,13H KM, RANGE     LL 09160
   * ,F7.3,3H KM)                                                       LL 09170
408 FORMAT(//10X,51H SLANT PATH BETWEEN ALTITUDES H1 AND H2 WHERE H1    LL 09180
   * ,F7.3,9H KM H2 = ,F7.3,20H KM, ZENITH ANGLE = ,F7.3,8H DEGREES)    LL 09190
409 FORMAT(//10X,40H SLANT PATH TO SPACE FROM ALTITUDE H1 = ,F7.3,19H   LL 09200
   *KM, ZENITH ANGLE =,F7.3,8H DEGREES)                                 LL 09210
410 FORMAT('1'/10X,41H TROPICAL (15 DEG. LAT.) MODEL ATMOSPHERE)        LL 09220
411 FORMAT('1'/10X,51H MIDLATITUDE (45 DEG. LAT.) SUMMER MODEL ATMOSP   LL 09230
   *ERE)                                                                LL 09240
412 FORMAT('1'/10X,51H MIDLATITUDE (45 DEG. LAT.) WINTER MODEL ATMOSP   LL 09250
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     *ERE)                                                              LL 09260
413   FORMAT('1'/10X,50H SUB-ARCTIC (60 DEG. LAT.) SUMMER MODEL ATMOSPHELL 09270
     *RE)                                                               LL 09280
414   FORMAT('1'/10X,50H SUB-ARCTIC (60 DEG. LAT.) WINTER MODEL ATMOSPHELL 09290
     *RE)                                                               LL 09300
415   FORMAT('1'//10X,36H 1962 U.S. STANDARD ATMOSPHERE MODEL)           LL 09310
417   FORMAT(/10X,14H HAZE MODEL = ,F5.1,29H KM VISUAL RANGE AT SEA LEVELL 09320
     *L/)                                                               LL 09330
418   FORMAT(/10X,22H FREQUENCY RANGE V1 = ,F7.1,14H CM-1 TO V2 = ,F7.1,LL 09340
     *15H CM-1 FOR DV = ,F6.1,9H CM-1   (,F6.2,3H - ,F5.2,9H MICRONS)//)LL 09350
419   FORMAT(/10X,38H EQUIVALENT SEA LEVEL ABSORBER AMOUNTS//21X,110HWATLL 09360
     *ER VAPOR       CO2 ETC.       OZONE     NITROGEN (CONT)   H2O (CONT) LL 09370
     *    MOL  SCAT       AEROSOL      OZONE(U-V)/24X,7HGM CM-2,10X,2HKM, LL 09380
     *10X,6HATM CM,10X,2HKM,9X,7HGM CM-2,10X,2HKM,13X,2HKM,10X,6HATM CM)LL 09390
420   FORMAT('1'///10X,21H  VERTICAL PROFILES  ,63X,3HPSI,4X,3HPHI,6X,  LL 09400
     *4HBETA,4X,13HTHETA   RANGE)                                       LL 09410
421   FORMAT(/8X,10H W(1-8) = ,8(1PE14.3)/74X,1PE14.3/)                  LL 09420
422   FORMAT('1'/10X,32H  FREQ WAVELENGTH  TOTAL      H2O,5X,4HCO2+,5X,  LL 09430
     *64HCZCNE  N2 CCNT  H2O CONT MOL SCAT  AEROSOL  AEROSOL   INTEGRATELL 09440
     *D /11X,14H CM-1  MICRONS,8(4X,5HTRANS),4X,20H ABS     ABSORPTION )LL 09450
423   FORMAT(10X,I6,10F9.4,F12.2)                                        LL 09460
424   FORMAT(/27H INTEGRATED ABSORPTION FROM ,I5,4H TO ,I5,8H CM-1 = ,   LL 09470
     *F10.2,26H, AVERAGE TRANSMITTANCE = ,F6.4)                         LL 09480
426   FORMAT(/20X,42HAEROSOL SCATTERING NOT COMPUTED, IHAZE = 0)         LL 09490
427   FORMAT('1'///10X,20H HORIZONTAL PROFILES)                          LL 09500
428   FORMAT(/10X,6H H1 = ,F7.3,10H KM, H2 = ,F7.3,13H KM, ANGLE = ,     LL 09510
     *F8.4,14H GEOM. RANGE = ,F7.2,12H KM, BETA = ,F8.5,4H DEG)         LL 09520
429   FORMAT(3F10.3,2F5.2,2(1PE10.3),F10.3)                              LL 09530
430   FORMAT(10X,26HINPUT METEOROLOGICAL DATA /10X,4HZ = ,F7.2,9H KM, P LL 09540
     *= ,F7.2,9H MB, T = ,F5.1,18H C, DEW PT.TEMP = ,F5.1,19H C, REL HUMLL 09550
     *IDITY = ,F5.1,18H %, H2O DENSITY = ,1PE9.2,7H GM.M-3/10X,17H OZONELL 09560
     * DENSITY = ,1PE9.2,17H GM.M-3, RANGE = ,F10.3,3H KM)              LL 09570
433   FORMAT(71H TRAJECTORY MISSES EARTH-S ATMOSPHERE. CLOSEST DISTANCE LL 09580
     *OF APPROACH IS ,F10.2/19H END OF CALCULATION)                     LL 09590
434   FORMAT(10X,I4,F6.1,11(1PE10.3))                                    LL 09600
435   FORMAT(I3,F6.1,8(1PE10.3),4(0PF9.4),F6.1)                          LL 09610
436   FORMAT(8H HMIN = ,F10.3)                                           LL 09620
437   FORMAT(64H PATH INTERSECTS EARTH - PATH CHANGED TO TYPE 2 WITH H2 LL 09630
     *= 0.0 KM)                                                         LL 09640
438   FORMAT(85H CHOICE OF TWO PATHS FOR THIS CASE - SHORTER PATH TAKEN LL 09650
     *  FOR LONGER PATH SET LEN = 1)                                    LL 09660
439   FORMAT(85H CHOICE OF TWO PATHS FOR THIS CASE - LONGER PATH TAKEN. LL 09670
     * FOR SHORTER PATH SET LEN = 0)                                    LL 09680
440   FORMAT(70H H2 WAS SET LESS THAN HMIN AND HAS BEEN RESET EQUAL TO  LL 09690
     *MIN I.E., H2 = ,F10.3)                                            LL 09700
441   FORMAT(24H  MODEL ATMOSPHERE NO. 7/23H    Z (KM)    P (MB)     ,  LL 09710
     * 49HT (C)  DEW PT _RH  H2O(GM.M-3) O3(GM.M-3) NO. DEN.)           LL 09720
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442   FORMAT(61H  FOG CONDITIONS MAY EXIST AT SEA LEVEL FOR THIS VISUAL LL 09730
     *RANGE/93H  IF SO THEN ASSUME THE TRANSMITTANCE DUE TO FOG IS GIVENLL 09740
     *BY THE TRANSMITTANCE AT 0.55 MICRONS)                              LL 09750
443   FORMAT(//5X,29HESTIMATED TANGENT ALTITUDE =  ,F10.3,3H KM//)       LL 09760
444   FORMAT(15X,41HTEMPERATURE PROFILE FOR MODEL ATMOSPHERE ,I5)        LL 09770
445   FORMAT(15X,41HWATER VAPOR PROFILE FOR MODEL ATMOSPHERE ,I5)        LL 09780
446   FORMAT(15X,41HOZONE        PROFILE FOR MODEL ATMOSPHERE ,I5)       LL 09790
447   FORMAT(/10X,26H CONTINENTAL AEROSOL MODEL)                         LL 09800
448   FORMAT(/10X,20H RURAL AEROSOL MODEL)                               LL 09810
449   FORMAT(/10X,20H URBAN AEROSOL MODEL)                               LL 09820
450   FORMAT(/10X,23H MARITIME AEROSOL MODEL)                            LL 09830
451   FORMAT(10H1   ***   ,I5,37H INPUT LEVELS EXCEEDS MODEL LIMIT OF ,  LL 09840
     *I5)                                                                LL 09850
      END                                                                LL 09860
      SUBROUTINE POINT (X,YN,N,NP,TX,IP)                                 LL 09870
C                                                                        LL 09880
C*********************************************************************LL 09890
C*                                                                    *LL 09900
C*    SUBROUTINE POINT COMPUTES THE MEAN REFRACTIVE INDEX ABOVE AND   *LL 09910
C*    BELOW A GIVEN ALTITUDE AND INTERPOLATES EXPONENTIALLY TO DETER- *LL 09920
C*    MINE THE EQUIVALENT ABSORBER AMOUNTS AT THAT ALTITUDE.          *LL 09930
C*                                                                    *LL 09940
C*********************************************************************LL 09950
C*                                                                    *LL 09960
C*    X IS THE GIVEN ALTITUDE IN KM.                                  *LL 09970
C*    TX(9) AND YN ARE THE MEAN REFRACTIVITY ABOVE AND BELOW X,       *LL 09980
C*      RESPECTIVELY.                                                 *LL 09990
C*    N IS THE INTEGER CORRESPONDING TO THE ATMOSPHERIC LEVEL AT      *LL 10000
C*      OR BELOW X.                                                   *LL 10010
C*    IF X COINCIDES WITH THE ATMOSPHERE LEVEL, NP = 1,               *LL 10020
C*      OTHERWISE NP = 0.                                             *LL 10030
C*    TX(1-8) ARE ABSORBER AMOUNTS PER KM AT X.                       *LL 10040
C*    IP IS AN INDICATOR'  IP = 0 IMPLIES A CALCULATION OF REFRACTIVE *LL 10050
C*      INDEX ONLY.  OTHERWISE, THE EQUIVALENT ABSORBER AMOUNTS ARE   *LL 10060
C*      ALSO CALCULATED.                                              *LL 10070
C*                                                                    *LL 10080
C*********************************************************************LL 10090
C                                                                        LL 10100
      COMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),Z0(34),P01(34),P02(34),    LL 01270
     *P03(34),P04(34),P05(34),P06(34),T01(34),T02(34),T03(34),T04(34),   LL 01280
     *T05(34),T06(34),WH01(34),WH02(34),WH03(34),WH04(34),WH05(34),      LL 01280
     *WH06(34), WO01(34),WO02(34),WO03(34),WO04(34),WO05(34),WO06(34),   LL 01280
     *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),      LL 01280
     *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),       LL 01280
     *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),       LL 01280
     *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),     LL 01280
     *C702(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),          LL 01280
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     *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),                LL 01280
     *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)                   LL 01390
C                                                                           LL 10240
      DIMENSION          TX(10),P(7,34),T(7,34),WH(7,34),WO(7,34),VX(4,45)LL 10250
     *                  ,C7(4,45),C7A(4,45),C1(2580),C2(1575)
      LOGICAL            CKZERO                                            LL 10260
C                                                                           LL 10270
      REF(X,Y,Z)=CO*X/Y-4.56E-6*Z*Y*CW                                      LL 10280
      CKZERO(X)=ABS(X).LT.1.E-20                                            LL 10290
C                                                                           LL 10300
      CALL ARRAY(P,T,WH,WO,VX,C1,C2,C7,C7A)                                 LL 01470
      N=0                                                                   LL 10310
      X=AMAX1(X,0.0)                                                        LL 10320
      NL1=NL-1                                                              LL 10330
      DO 101  I = 1,NL1                                                     LL 10340
 101     IF (X.GT.Z(I))  N=I                                                LL 10350
      IF (.NOT.CKZERO(X-Z(N+1)))  NP=0                                      LL 10360
      IF (      CKZERO(X-Z(N+1)))  NP=1                                     LL 10370
      IF (N.EQ.0.OR.NP.EQ.1)  GO TO 102                                     LL 10380
      FAC=AMIN1((X-Z(N))/(Z(N+1)-Z(N)),1.)                                  LL 10390
      PX1=P(M,N)*(P(M,N+1)/P(M,N))**FAC                                     LL 10400
      TX1=T(M,N)*(T(M,N+1)/T(M,N))**FAC                                     LL 10410
      WX1=WH(M,N)*(WH(M,N+1)/WH(M,N))**FAC                                  LL 10420
      TX(9)=(REF(P(M,N+1),T(M,N+1),WH(M,N+1))+REF(PX1,TX1,WX1))/2.          LL 10430
      YN=(REF(P(M,N),T(M,N),WH(M,N))+REF(PX1,TX1,WX1))/2.                   LL 10440
      GO TO 103                                                             LL 10450
C                                                                           LL 10460
 102  CONTINUE                                                              LL 10470
      TX(9)=(EH(9,N+1)-1.)*1.E+06                                           LL 10480
      IF (N.EQ.0)  YN=0.0                                                   LL 10490
      IF (N.NE.0)  YN=(EH(9,N)-1.)*1.E+06                                   LL 10500
 103  CONTINUE                                                              LL 10510
C                                                                           LL 10520
      IF (IP.EQ.0)  GO TO 105                                               LL 10530
      DO 104 K = 1,10                                                       LL 10540
         IF ((N.EQ.0.OR.      CKZERO(EH(K,N))).AND.K.NE.9)  TX(K)=0.0       LL 10550
         IF ((N.NE.0.AND..NOT.CKZERO(EH(K,N))).AND.K.NE.9)  TX(K)=          LL 10560
     *       EH(K,N)*(EH(K,N+1)/EH(K,N))**FAC                               LL 10570
 104     CONTINUE                                                           LL 10580
      WRITE(6,1)  X,N,NP,TX(9),YN,(TX(K),K=1,8)                             LL 10590
 105  CONTINUE                                                              LL 10600
      TX(9)=1.+TX(9)*1.E-06                                                 LL 10610
      YN   =1.+YN*1.E-06                                                    LL 10620
      RETURN                                                                LL 10630
    1 FORMAT(/,10X,'FROM POINT - HEIGHT =' ,F10.4,9H KM, N =  ,I3,7H, NP    LL 10640
     * =,I2,35H, REFRACTIVITY ABOVE AND BELOW X = ,2(1PE10.3)//10X,          LL 10650
     *40H EQUIVALENT ABSORBER AMOUNTS PER KM AT X//20X,8(1PE10.3))          LL 10660
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      END                                                               LL 10670
C
C
C
      SUBROUTINE ANGL (H1,H2,ANGLE,BETA,LEN,ML)                         LL 10680
C                                                                       LL 10690
C*********************************************************************LL 10700
C*                                                                    *LL 10710
C*    THIS SUBROUTINE CALCULATES THE INITIAL ZENITH ANGLE (ANGLE)     *LL 10720
C*    TAKING INTO ACCOUNT REFRACTION EFFECTS GIVEN H1,H2, AND BETA    *LL 10730
C*    (WHERE BETA IS THE EARTH CENTRE ANGLE SUBTENDED BY H1 AND H2 ),  *LL 10740
C*    ASSUMING THE REFRACTIVE INDEX TO BE CONSTANT IN A GIVEN LAYER.  *LL 10750
C*    FOR GREATER ACCURACY INCREASE THE NUMBER OF LEVELS IN THE MODEL *LL 10760
C*    ATMOSPHERE.                                                     *LL 10770
C*                                                                    *LL 10780
C*    THIS SUBROUTINE CAN BE REMOVED FROM THE PROGRAM IF NOT REQUIRED. *LL 10790
C*                                                                    *LL 10800
C*********************************************************************LL 10810
C                                                                       LL 10820
      COMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),Z0(34),P01(34),P02(34),   LL 01270
     *P03(34),P04(34),P05(34),P06(34),T01(34),T02(34),T03(34),T04(34),  LL 01280
     *T05(34),T06(34),WH01(34),WH02(34),WH03(34),WH04(34),WH05(34),    LL 01280
     *WH06(34), WO01(34),WO02(34),WO03(34),WO04(34),WO05(34),WO06(34),  LL 01280
     *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),    LL 01280
     *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),     LL 01280
     *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),     LL 01280
     *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),   LL 01280
     *C702(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),        LL 01280
     *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),           LL 01280
     *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)              LL 01390
C                                                                       LL 10960
      DIMENSION          TX(10)                                         LL 10970
      LOGICAL            CKZERO                                         LL 10980
C                                                                       LL 10990
      CKZERO(X)=ABS(X).LT.1.E-20                                        LL 11000
C                                                                       LL 11010
      IP=99                                                             LL 11020
      X1=RE+H1                                                          LL 11030
      X2=RE+H2                                                          LL 11040
      LEN=0                                                             LL 11050
      BETA=BETA*CA                                                      LL 11060
      IF (CKZERO(BETA)) BETA=ARCOS(X2/X1)                               LL 11070
      TANG=X2*SIN(BETA)/(X2*COS(BETA)-X1)                               LL 11080
      THET=ATAN(TANG)                                                   LL 11090
      IF (THET.LT.0.0) THET=THET+PI                                     LL 11100
      SPHI=SIN(THET)                                                    LL 11110
      ANG=THET/CA                                                       LL 11120
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      TN=THET                                                           LL 11130
      TM=TN-0.5*CA                                                      LL 11140
      DO 101 ITER =  1,10                                               LL 11150
         ANGLE=THET                                                     LL 11160
         FBT=0.0                                                        LL 11170
         B1=0.0                                                         LL 11180
         BET1=0.0                                                       LL 11190
         BET2=0.0                                                       LL 11200
         FBT1=0.0                                                       LL 11210
         FBT2=0.0                                                       LL 11220
         FBT3=0.0                                                       LL 11230
         IF (BETA.LE.0.0) GO TO 2                                       LL 11240
         IF (2.*THET-PI.GT.1.E-8) GO TO 9                               LL 11250
         IF (IP.EQ.100) GO TO 6                                         LL 11260
         XMIN=X2*COS(BETA)-RE                                           LL 11270
         IF (XMIN.LT.H1) GO TO 8                                        LL 11280
         IF (XMIN.GE.H1) GO TO 4                                        LL 11290
2        HMIN=H2                                                        LL 11300
         H2=H1                                                          LL 11310
         H1=HMIN                                                        LL 11320
3        ANGLE=0.5*PI                                                   LL 11330
         THET=ANGLE                                                     LL 11340
         SPHI=1.0                                                       LL 11350
         ANG=ANGLE/CA                                                   LL 11360
4        IP=100                                                         LL 11370
         CALL POINT (H1,YN,J1,NP,TX,IP)                                 LL 11380
         TX1=TX(9)                                                      LL 11390
5        CALL POINT (H2,YN,J2,NP,TX,IP)                                 LL 11400
         IF (NP.EQ.1) J2=J2-1                                           LL 11410
         IF (J1.EQ.J2) TX1=TX1+YN-EH(9,J1)                              LL 11420
6        CONTINUE                                                       LL 11430
         X1=RE+H1                                                       LL 11440
         FBT=-TAN(THET)                                                 LL 11450
         DO 7 J = J1,J2                                                 LL 11460
            IF (J.NE.J2) X2=RE+Z(J+1)                                   LL 11470
            IF (J.EQ.J2) X2=RE+H2                                       LL 11480
            SALP=X1*SPHI/X2                                             LL 11490
            ALP=ARSIN(SALP)                                             LL 11500
            RN=EH(9,J+1)/EH(9,J)                                        LL 11510
            IF ((J+1).EQ.J2) RN=YN/EH(9,J)                              LL 11520
            IF (J.EQ.J1) RN=EH(9,J+1)/TX1                               LL 11530
            IF ((J+1).EQ.J2.AND.J.EQ.J1) RN=YN/TX1                      LL 11540
            FBT=FBT+TAN(THET)-TAN(ALP)                                  LL 11550
            E1=B1+THET-ALP                                              LL 11560
            TH1=THET/CA                                                 LL 11570
            C=ALP/CA                                                    LL 11580
            IF (CKZERO(X2-(RE+H2))) C=PI-ALP                            LL 11590
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      IF (SALP.GE.RN) RN=1.                                             LL 11600
      SPHI=SALP/RN                                                      LL 11610
      THET=ARSIN(SPHI)                                                  LL 11620
      X1=X2                                                             LL 11630
7     CONTINUE                                                          LL 11640
    IF (BETA.LE.0.0) THET=C                                             LL 11650
    IF (BETA.LE.0.0) GO TO 28                                           LL 11660
    GO TO 26                                                            LL 11670
8   CONTINUE                                                            LL 11680
    TANG=-TANG                                                          LL 11690
    ANGLE=PI-ANGLE                                                      LL 11700
    TN=ANGLE                                                            LL 11710
    ANG=ANGLE/CA                                                        LL 11720
    IF (H1.LE.0.0) GO TO 3                                              LL 11730
9   CONTINUE                                                            LL 11740
    IP=101                                                              LL 11750
    CALL POINT (H1,YN1,J1,NP1,TX,IP)                                    LL 11760
    TX1=TX(9)                                                           LL 11770
    IF (NP1.EQ.1) J1=J1-1                                               LL 11780
    J2=ML                                                               LL 11790
    IF (H2.GE.H1) GO TO 13                                              LL 11800
    CALL POINT (H2,YN2,J2,NP2,TX,IP)                                    LL 11810
    TX2=TX(9)                                                           LL 11820
    IF (J1.EQ.J2) TX2=YN1+TX(9)-EH(9,J1)                                LL 11830
    J2P=J2-1                                                            LL 11840
    DO 102 J = J1,J2P                                                   LL 11850
      X1=RE+Z(J+1)                                                      LL 11860
      X2=RE+Z(J)                                                        LL 11870
      IF (J.EQ.J1) X1=RE+H1                                             LL 11880
      IF (J.EQ.J2) X2=RE+H2                                             LL 11890
      SALP=X1*SPHI/X2                                                   LL 11900
      HMIN=X1*SPHI-RE                                                   LL 11910
      IF (SALP.LE.1.0) GO TO 11                                         LL 11920
      SALP=SPHI                                                         LL 11930
      IF (HMIN.GT.H2) GO TO 18                                          LL 11940
11    ALP=ARSIN(SALP)                                                   LL 11950
      THET=ARSIN(SPHI)                                                  LL 11960
      BET=ALP-THET                                                      LL 11970
      BET1=BET1+BET                                                     LL 11980
      FB=TAN(ALP)                                                       LL 11990
      IF (J.NE.J1) FB=FB-TAN(THET)                                      LL 12000
      FBT1=FBT1+FB                                                      LL 12010
      TH1=THET/CA                                                       LL 12020
      BE=BET/CA                                                         LL 12030
      AL=ALP/CA                                                         LL 12040
      IF (CKZERO(X2-(RE+H2))) C=PI-ALP                                  LL 12050
      REF=EH(9,J)                                                       LL 12060
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      IF (J.EQ.J1) REF=YN1                                              LL 12070
      IF (J.EQ.J2) REF=TX2                                              LL 12080
      IF (J.EQ.1) GO TO 12                                              LL 12090
      RN=EH(9,J)/EH(9,J-1)                                              LL 12100
      IF (J.EQ.J1) RN=YN1/EH(9,J-1)                                     LL 12110
      IF (J.EQ.J2+1) RN=REF/TX2                                         LL 12120
      IF (J.EQ.J2) RN=REF/YN2                                           LL 12130
      IF (SALP.GE.RN) RN=1.                                             LL 12140
      SPHI=SALP*RN                                                      LL 12150
      IF (Z(J).LE.H2) GO TO 12                                          LL 12160
102   CONTINUE                                                          LL 12170
 12   X1=X2                                                             LL 12180
      IF (ABS(Z(J)-H2).GE.1.0E-10.OR.J.EQ.1) GO TO 14                   LL 12190
 13   J=J-1                                                             LL 12200
      X1=RE+Z(J+1)                                                      LL 12210
      IF (J.EQ.J1) X1=RE+H1                                             LL 12220
      IF (J.EQ.J2.AND.J.NE.J1) X1=RE+H2                                 LL 12230
 14   X2=RE+Z(J)                                                        LL 12240
      HMIN=X1*SPHI-RE                                                   LL 12250
      IF (HMIN.LE.0.0) B1=BET1                                          LL 12260
      IF (HMIN.LE.0.0) LEN=0                                            LL 12270
      IF (HMIN.LE.0.0) FBT=FBT1                                         LL 12280
      IF (HMIN.LE.0.0) GO TO 26                                         LL 12290
      IF (Z(J).LT.HMIN) GO TO 18                                        LL 12300
      REF=EH(9,J)                                                       LL 12310
      IF (J.EQ.J2) REF=YN                                               LL 12320
      SALP=X1*SPHI/X2                                                   LL 12330
    ALP=ARSIN(SALP)                                                     LL 12340
    THET=ARSIN(SPHI)                                                    LL 12350
      BET=ALP-THET                                                      LL 12360
      FB=TAN(ALP)-TAN(THET)                                             LL 12370
      FBT2=FBT2+FB                                                      LL 12380
      BET2=BET2+BET                                                     LL 12390
      BMIN=BET1+BET2                                                    LL 12400
      AL=ALP/CA                                                         LL 12410
      TH1=THET/CA                                                       LL 12420
      RN=REF/EH(9,J-1)                                                  LL 12430
      IF (SALP.GE.RN) RN=1.0                                            LL 12440
      SPHI=SALP*RN                                                      LL 12450
      GO TO 13                                                          LL 12460
 17   TX3=YN1+TX(9)-EH(9,J1)                                            LL 12470
      YN1=TX3                                                           LL 12480
      IF (ABS(H2-Z(J+1)).LE.1.0E-5) YN1=TX(9)                           LL 12490
      IF (ABS(H1-Z(J+1)).LE.1.0E-5) YN1=TX(9)                           LL 12500
      RN=1.0                                                            LL 12510
      GO TO 19                                                          LL 12520
 18   CALL POINT (HMIN,YN,J2,NP,TX,IP)                                  LL 12530
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      IP=102                                                            LL 12540
      TX3=TX(9)                                                         LL 12550
      IF (J.EQ.J1.AND.H2.GE.H1) GO TO 17                                LL 12560
      IF (J.EQ.J1.OR.J.EQ.J2) TX3=YN2+TX(9)-EH(9,J)                     LL 12570
      IF (HMIN.GT.H2) TX3=TX(9)                                         LL 12580
      IF (J.EQ.J1.AND.HMIN.GT.H2) GO TO 17                              LL 12590
      RN=REF/TX3                                                        LL 12600
      IF (SALP.GE.FN) RN=1.                                             LL 12610
      SPHI=SALP*RN                                                      LL 12620
      X=X1*SPHI-RE                                                      LL 12630
      DIF=ABS(HMIN-X)                                                   LL 12640
      HMIN=X                                                            LL 12650
      IF (DIF.GT.1.0E-5) GO TO 18                                       LL 12660
19    X2=RE+HMIN                                                        LL 12670
         THET=ARSIN(SPHI)                                               LL 12680
      IF (CKZERO(RN)) FBT3=-TAN(THET)                                   LL 12690
      IF (CKZERO(RN)) GO TO 20                                          LL 12700
      DNX=(TX3-1.0)*ALOG((TX3-1.0)/(REF-1.0))/(X2-X1)                   LL 12710
      FBT3=-TAN(THET)*(1.0-1.0/(1.0+TX3/(X2*DNX)))                      LL 12720
20    BET=0.5*PI-THET                                                   LL 12730
      BET2=BET2+BET                                                     LL 12740
      BMIN=BET1+BET2                                                    LL 12750
      IF (H2.GE.H1) GO TO 23                                            LL 12760
      BET=BET1+2.*BET2                                                  LL 12770
      DB1=BETA-BET1                                                     LL 12780
      DB2=BET-BETA                                                      LL 12790
      DB3=ABS(BMIN-BETA)                                                LL 12800
      IF ((DB3.GT.DB1.OR.DB3.GE.DB2).AND.DB2.GT.DB1) B1=BET1            LL 12810
      IF ((DB3.GT.DB1.OR.DB3.GE.DB2).AND.DB2.GT.DB1) LEN=0              LL 12820
      IF ((DB3.GT.DB1.OR.DB3.GE.DB2).AND.DB2.GT.DB1) FBT=FBT1           LL 12830
      IF ((DB3.LE.DB1.OR.DB2.LE.DB1).AND.DB3.LE.DB1) B1=BET1+BET2       LL 12840
      IF ((DB3.LE.DB1.OR.DB2.LE.DB1).AND.DB3.LE.DB1) FBT=FBT1+FBT2+     LL 12850
     *   FBT3                                                           LL 12860
      IF (DB3.GE.DB2.AND.DB2.LE.DB1) B1=BET                             LL 12870
      IF (DB3.GE.DB2.AND.DB2.LE.DB1) LEN=1                              LL 12880
      IF (DB3.GE.DB2.AND.DB2.LE.DB1) FBT=FBT1+2.*(FBT2+FBT3)            LL 12890
      GO TO 26                                                          LL 12900
23    B1=2.0*(BET1+BET2)                                                LL 12910
      LEN=1.                                                            LL 12920
      FBT=2.0*(FBT1+FBT2+FBT3)                                          LL 12930
      WRITE(6,401) J,B1,FBT,FBT1,FBT2,FBT3,TX1,YN1                      LL 12940
      IF (CKZERO(H2-H1)) GO TO 26                                       LL 12950
      IP=103                                                            LL 12960
      IF (NP1.EQ.1) J1=J1+1                                             LL 12970
      SPHI=SIN(ANGLE)                                                   LL 12980
      IF (Z(J1+1).LE.H2) CALL POINT(H2,YN,N,NP,TX,IP)                   LL 12990
      IF (Z(J1+1).LE.H2) J2=J1                                          LL 13000
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      RN=TX1/YN1                                                        LL 13010
      IF (SPHI.GE.RN) RN=1.                                             LL 13020
      SPHI=SPHI/RN                                                      LL 13030
         THET=ARSIN(SPHI)                                               LL 13040
      GO TO 5                                                           LL 13050
 26   THET=ANGLE+(BETA-B1)/(1.+FBT/TANG)                                LL 13060
      DB1=B1/CA                                                         LL 13070
      B=BET1/CA                                                         LL 13080
      TH1=THET/CA                                                       LL 13090
      WRITE(6,404) B1,DB1,FBT,TH1,TANG                                  LL 13100
      IF (THET.GT.TN.OR.THET.LT.TM) THET=(TN+TM)/2.                     LL 13110
      TH1=THET/CA                                                       LL 13120
      WRITE(6,404) BET1,B,FBT,TH1                                       LL 13130
      TN1=TN/CA                                                         LL 13140
      TM1=TM/CA                                                         LL 13150
      WRITE(6,405) TN,TM,TN1,TM1                                        LL 13160
      SPHI=SIN(THET)                                                    LL 13170
      TANG=TAN(THET)                                                    LL 13180
      IF (ABS(BETA-B1).LT.1.E-7.OR.ABS(ANGLE-THET).LT.1.E-7) GO TO 28LL 13190
 101  CONTINUE                                                          LL 13200
    THET=(ANGLE+THET)/2.                                                LL 13210
 28 ANGLE=THET/CA                                                       LL 13220
    IF (BETA.LE.0.0) H1=H2                                              LL 13230
    WRITE(6,406) ANGLE,ITER                                             LL 13240
    RETURN                                                              LL 13250
C                                                                       LL 13260
 401 FORMAT (I6,1PE16.7,8(0PF13.8))                                     LL 13270
 404 FORMAT (14H TOTAL BETA = ,1PE14.6,0PF15.6,7H, FBT = ,1PE14.6,8H THLL 13280
    *ET = ,0PF10.6,8H TANG = ,F10.6,15H TOTAL RANGE = ,F10.1)           LL 13290
 405 FORMAT (5F12.6)                                                    LL 13300
 406 FORMAT (8X/15HZENITH ANGLE = ,F7.3,53H DEGREES - RECOMPUTED FROM SLL 13310
    *UBROUTINE ANGL (ITERATION,I3,1H))                                  LL 13320
    END                                                                 LL 13330
C
C
C
    SUBROUTINE ARRAY(P,T,WH,WO,VX,C1,C2,C7,C7A)                         LL 13340
C
    COMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),ZO(34),PO1(34),PO2(34),     LL 01270
   *PO3(34),PO4(34),PO5(34),PO6(34),TO1(34),TO2(34),TO3(34),TO4(34),    LL 01280
   *TO5(34),TO6(34),WHO1(34),WHO2(34),WHO3(34),WHO4(34),WHO5(34),       LL 01280
   *WHO6(34), WOO1(34),WOO2(34),WOO3(34),WOO4(34),WOO5(34),WOO6(34),    LL 01280
   *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),       LL 01280
   *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),        LL 01280
   *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),        LL 01280
   *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),      LL 01280
   *C702(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),           LL 01280
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      *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),          LL 01280
      *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)              LL 01390
       DIMENSION P(7,34),T(7,34),WH(7,34),WO(7,34),VX(4,45),           LL 13480
      *          C1(2580),C2(1575),C7(4,45),C7A(4,45)
C
C
       DO 10 I=1,34                                                    LL 13490
       P(1,I)=P01(I)                                                   LL 13500
       P(2,I)=P02(I)                                                   LL 13510
       P(3,I)=P03(I)                                                   LL 13520
       P(4,I)=P04(I)                                                   LL 13530
       P(5,I)=P05(I)                                                   LL 13540
       P(6,I)=P06(I)                                                   LL 13550
       T(1,I)=T01(I)                                                   LL 13570
       T(2,I)=T02(I)                                                   LL 13580
       T(3,I)=T03(I)                                                   LL 13590
       T(4,I)=T04(I)                                                   LL 13600
       T(5,I)=T05(I)                                                   LL 13610
       T(6,I)=T06(I)                                                   LL 13620
       WH(1,I)=WH01(I)                                                 LL 13640
       WH(2,I)=WH02(I)                                                 LL 13650
       WH(3,I)=WH03(I)                                                 LL 13660
       WH(4,I)=WH04(I)                                                 LL 13670
       WH(5,I)=WH05(I)                                                 LL 13680
       WH(6,I)=WH06(I)                                                 LL 13690
       WO(1,I)=WO01(I)                                                 LL 13710
       WO(2,I)=WO02(I)                                                 LL 13720
       WO(3,I)=WO03(I)                                                 LL 13730
       WO(4,I)=WO04(I)                                                 LL 13740
       WO(5,I)=WO05(I)                                                 LL 13750
       WO(6,I)=WO06(I)                                                 LL 13760
   10  CONTINUE                                                        LL 13780
       DO 20 I=1,45
        VX(1,I)=VX01(I)
        VX(2,I)=VX02(I)
        VX(3,I)=VX03(I)
        VX(4,I)=VX04(I)
   20  CONTINUE
       DO 30 I=1,45
       C7(1,I)=C701(I)                                                 LL 13640
       C7(2,I)=C702(I)                                                 LL 13650
       C7(3,I)=C703(I)                                                 LL 13660
       C7(4,I)=C704(I)                                                 LL 13670
       C7A(1,I)=C7A01(I)                                               LL 13640
       C7A(2,I)=C7A02(I)                                               LL 13650
       C7A(3,I)=C7A03(I)                                               LL 13660
       C7A(4,I)=C7A04(I)                                               LL 13670
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   30 CONTINUE
      DO 40 I=1,190
      C1(I)=C101(I)                                                     LL 13640
      C1(I+190)=C102(I)                                                 LL 13650
      C1(I+380)=C103(I)                                                 LL 13660
      C1(I+570)=C104(I)                                                 LL 13670
      C1(I+760)=C105(I)                                                 LL 13680
      C1(I+950)=C106(I)                                                 LL 13690
      C1(I+1140)=C107(I)                                                LL 13700
      C1(I+1330)=C108(I)                                                LL 13710
      C1(I+1520)=C109(I)                                                LL 13720
      C1(I+1710)=C110(I)                                                LL 13730
      C1(I+1900)=C111(I)                                                LL 13740
      C1(I+2090)=C112(I)                                                LL 13750
      C1(I+2280)=C113(I)                                                LL 13760
      C2(I)=C201(I)                                                     LL 13640
      C2(I+190)=C202(I)                                                 LL 13650
      C2(I+380)=C203(I)                                                 LL 13660
      C2(I+570)=C204(I)                                                 LL 13670
      C2(I+760)=C205(I)                                                 LL 13670
   40 CONTINUE                                                          LL 13780
      DO 50 I=1,110
      C1(I+2470)=C114(I)
   50 CONTINUE
      RETURN                                                            LL 13790
      END                                                               LL 13800
C
      BLCCK DATA                                                        LL 13810
C                                                                       LL 13820
C*****************************************************************LL 13830
C*    THE SPECTRAL AND TRANSMITTANCE DATA FOR LOWTRAN IIIB.          *LL 13850
C*****************************************************************LL 13870
C                                                                       LL 13880
      CCMMON /LOWTRN/ IATM,NL,HZ1(34),HZ2(34),ZO(34),PO1(34),PO2(34),   LL 01270
     *PO3(34),PO4(34),PO5(34),PO6(34),TO1(34),TO2(34),TO3(34),TO4(34),  LL 01280
     *TO5(34),TO6(34),WHO1(34),WHO2(34),WHO3(34),WHO4(34),WHO5(34),     LL 01280
     *WHO6(34), WOO1(34),WOO2(34),WOO3(34),WOO4(34),WOO5(34),WOO6(34),  LL 01280
     *TR(67),FW(67),FO(67),C101(190),C102(190),C103(190),C104(190),     LL 01280
     *C105(190),C106(190),C107(190),C108(190),C109(190),C110(190),      LL 01280
     *C111(190),C112(190),C113(190),C114(110),C201(190),C202(190),      LL 01280
     *C203(190),C204(190),C205(190),C3(540),C4(133),C5(15),C701(45),    LL 01280
     *C702(45),C703(45),C704(45),C7A01(45),C7A02(45),C7A03(45),         LL 01280
     *C7A04(45),C8(102),VX01(45),VX02(45),VX03(45),VX04(45),            LL 01280
     *EH(10,34),M,M1,M2,M3,RE,CW,CO,PI,CA,REARTH(7),Z(34)               LL 01390
C                                                                       LL 14020
C *** THE VALUE FOR PI                                                  LL 14170
C                                                                       LL 14180
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      DATA              PI /3.14159265358979/                           LL 14190
C                                                                       LL 14200
C *** THE CONVERSION FROM DEGREES TO RADIANS.                           LL 14210
C                                                                       LL 14220
      DATA              CA /0.017453292519943/                          LL 14230
C                                                                       LL 14240
C *** THE MEAN RADIUS OF THE EARTH (INTERNATIONAL SPHERIOD) IN KM.      LL 14250
C                                                                       LL 14260
C     DATA              REBAR /6371.299315/                             LL 14270
C                                                                       LL 14280
C *** THE POLAR RADIUS OF THE EARTH (INTERNATIONAL SPHEROID) IN KM.     LL 14290
C                                                                       LL 14300
C     DATA              REPOL /6356.911946/                             LL 14310
C                                                                       LL 14320
C *** THE EQUATORIAL RADIUS OF THE EARTH (INTERNATIONAL SPHEROID) IN KM.LL 14330
C                                                                       LL 14340
C     DATA              REEQU /6378.388000/                             LL 14350
C                                                                       LL 14360
C *** VALUES OF THE RADIUS OF THE EARTH FOR THE MODEL ATMOSPHERES IN KM.LL 14370
C                                                                       LL 14380
      DATA              REARTH(1) /6376.951637/                         LL 14390
      DATA              REARTH(2) /6367.659029/                         LL 14400
      DATA              REARTH(3) /6367.659029/                         LL 14410
      DATA              REARTH(4) /6362.287754/                         LL 14420
      DATA              REARTH(5) /6362.287754/                         LL 14430
      DATA              REARTH(6) /6367.659029/                         LL 14440
      DATA              REARTH(7) /6371.299315/                         LL 14450
C                                                                       LL 14460
C *** NUMBER OF TYPES OF MODEL ATMOSPHERES                              LL 14470
C                                                                       LL 14480
      DATA              IATM /6/                                        LL 14490
C                                                                       LL 14500
C *** NUMBER OF LEVELS IN MODEL ATMOSPHERE DATA                         LL 14510
C                                                                       LI 14520
      DATA              NL /34/                                         LL 14530
C                                                                       LL 14540
C *** HAZE MODEL'  23 KM. VISIBLE RANGE                                 LL 14550
C                                                                       LL 14560
      DATA              HZ1 /2.830E+03,1.245E+03,5.374E+02,2.257E+02,   LL 14570
     *  1.193E+02,8.992E+01,6.341E+01,5.893E+01,6.073E+01,5.822E+01,    LL 14580
     *  5.679E+01,5.320E+01,5.589E+01,5.159E+01,5.052E+01,4.747E+01,    LL 14590
     *  4.514E+01,4.460E+01,4.317E+01,3.636E+01,2.669E+01,1.935E+01,    LL 14600
     *  1.456E+01,1.114E+01,8.831E+00,7.434E+00,2.239E+00,5.893E-01,    LL 14610
     *  1.551E-01,4.084E-02,1.078E-02,5.553E-05,1.970E-08,0.000E+00/    LL 14620
C                                                                       LL 14630
C *** HAZE MODEL'   5 KM. VISIBLE RANGE                                 LL 14640
C                                                                       LL 14650
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      DATA                HZ2 /1.379E+04,5.034E+03,1.845E+03,6.735E+02,     LL 14660
     *  2.454E+02,8.992E+01,6.341E+01,5.893E+01,6.073E+01,5.822E+01,       LL 14670
     *  5.679E+01,5.320E+01,5.589E+01,5.159E+01,5.052E+01,4.747E+01,       LL 14680
     *  4.514E+01,4.460E+01,4.317E+01,3.636E+01,2.669E+01,1.935E+01,       LL 14690
     *  1.456E+01,1.114E+01,8.831E+00,7.434E+00,2.239E+00,5.893E-01,       LL 14700
     *  1.551E-01,4.084E-02,1.078E-02,5.553E-05,1.970E-08,0.000E+00/       LL 14710
C                                                                          LL 14720
C *** ALTITUDE (KM.) AT LEVEL I                                            LL 14730
C                                                                          LL 14740
      DATA                Z0 / 0.0, 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0,LL 14750
     *      9.0,10.0,11.0,12.0,13.0,14.0,15.0,16.0,17.0,18.0,19.0,20.0,  LL 14760
     *     21.0,22.0,23.0,24.0,25.0,30.0,35.0,40.0,45.0,50.0,70.0,       LL 14770
     *     100.0,99999.0/                                                LL 14780
C                                                                          LL 14790
C *** PRESSURE (MB.) AT LEVEL I FOR THE MODEL ATMOSPHERES                  LL 14800
C                                                                          LL 14810
      DATA                P01                 /1.013E+03,9.040E+02,8.050E+02,  LL 14820
     *    7.150E+02,6.330E+02,5.590E+02,4.920E+02,4.320E+02,3.780E+02,   LL 14830
     *    3.290E+02,2.860E+02,2.470E+02,2.130E+02,1.820E+02,1.560E+02,   LL 14840
     *    1.320E+02,1.110E+02,9.370E+01,7.890E+01,6.660E+01,5.650E+01,   LL 14850
     *    4.800E+01,4.090E+01,3.500E+01,3.000E+01,2.570E+01,1.220E+01,   LL 14860
     *    6.000E+00,3.050E+00,1.590E+00,8.540E-01,5.790E-02,3.000E-04,   LL 14870
     *    0.000E+00/                                                     LL 14880
      DATA                P02                 /1.013E+03,9.020E+02,8.020E+02,  LL 14890
     *    7.100E+02,6.280E+02,5.540E+02,4.870E+02,4.260E+02,3.720E+02,   LL 14900
     *    3.240E+02,2.810E+02,2.430E+02,2.090E+02,1.790E+02,1.530E+02,   LL 14910
     *    1.300E+02,1.110E+02,9.500E+01,8.120E+01,6.950E+01,5.950E+01,   LL 14920
     *    5.100E+01,4.370E+01,3.760E+01,3.220E+01,2.770E+01,1.320E+01,   LL 14930
     *    6.520E+00,3.330E+00,1.760E+00,9.510E-01,6.710E-02,3.000E-04,   LL 14940
     *    0.000E+00/                                                     LL 14950
      DATA                P03                 /1.018E+03,8.973E+02,7.897E+02,  LL 14960
     *    6.938E+02,6.081E+02,5.313E+02,4.627E+02,4.016E+02,3.473E+02,   LL 14970
     *    2.992E+02,2.568E+02,2.199E+02,1.882E+02,1.610E+02,1.378E+02,   LL 14980
     *    1.178E+02,1.007E+02,8.610E+01,7.350E+01,6.280E+01,5.370E+01,   LL 14990
     *    4.580E+01,3.910E+01,3.340E+01,2.860E+01,2.430E+01,1.110E+01,   LL 15000
     *    5.180E+00,2.530E+00,1.290E+00,6.820E-01,4.670E-02,3.000E-04,   LL 15010
     *    0.000E+00/                                                     LL 15020
      DATA                P04                 /1.010E+03,8.960E+02,7.929E+02,  LL 15030
     *    7.000E+02,6.160E+02,5.410E+02,4.730E+02,4.130E+02,3.590E+02,   LL 15040
     *    3.107E+02,2.677E+02,2.300E+02,1.977E+02,1.700E+02,1.460E+02,   LL 15050
     *    1.250E+02,1.080E+02,9.280E+01,7.980E+01,6.860E+01,5.890E+01,   LL 15060
     *    5.070E+01,4.360E+01,3.750E+01,3.227E+01,2.780E+01,1.340E+01,   LL 15070
     *    6.610E+00,3.400E+00,1.810E+00,9.870E-01,7.070E-02,3.000E-04,   LL 15080
     *    0.000E+00/                                                     LL 15090
      DATA                P05                 /1.013E+03,8.878E+02,7.775E+02,  LL 15100
     *    6.798E+02,5.932E+02,5.158E+02,4.467E+02,3.853E+02,3.308E+02,   LL 15110
     *    2.829E+02,2.418E+02,2.067E+02,1.766E+02,1.510E+02,1.291E+02,   LL 15120
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     *     1.103E+02,9.431E+01,8.050E+01,6.882E+01,5.875E+01,5.014E+01,   LL 15130
     *     4.277E+01,3.647E+01,3.109E+01,2.649E+01,2.256E+01,1.020E+01,   LL 15140
     *     4.701E+00,2.243E+00,1.113E+00,5.719E-01,4.016E-02,3.000E-04,   LL 15150
     *     0.000E+00/                                                     LL 15160
      DATA                P06                /1.013E+03,8.986E+02,7.950E+02,  LL 15170
     *     7.012E+02,6.166E+02,5.405E+02,4.722E+02,4.111E+02,3.565E+02,   LL 15180
     *     3.080E+02,2.650E+02,2.270E+02,1.940E+02,1.658E+02,1.417E+02,   LL 15190
     *     1.211E+02,1.035E+02,8.850E+01,7.565E+01,6.467E+01,5.529E+01,   LL 15200
     *     4.729E+01,4.047E+01,3.467E+01,2.972E+01,2.549E+01,1.197E+01,   LL 15210
     *     5.746E+00,2.871E+00,1.491E+00,7.978E-01,5.520E-02,3.008E-04,   LL 15220
     *     0.000E+00/                                                     LL 15230
C                                                                         LL 15240
C                                                                         LL 15250
C     DATA   P07 /34*0.0/                                                 LL 15260
C                                                                         LL 15270
C                                                                         LL 15280
C                                                                         LL 15290
C *** TEMPERATURE (K) AT LEVEL I FOR THE MODEL ATMOSPHERES                LL 15300
C                                                                         LL 15310
      DATA                T01                /300.0,294.0,288.0,284.0,277.0,  LL 15320
     *     270.0,264.0,257.0,250.0,244.0,237.0,230.0,224.0,217.0,210.0,   LL 15330
     *     204.0,197.0,195.0,199.0,203.0,207.0,211.0,215.0,217.0,219.0,   LL 15340
     *     221.0,232.0,243.0,254.0,265.0,270.0,219.0,210.0,210.0/         LL 15350
      DATA                T02                /294.0,290.0,285.0,279.0,273.0,  LL 15360
     *     267.0,261.0,255.0,248.0,242.0,235.0,229.0,222.0,216.0,216.0,   LL 15370
     *     216.0,216.0,216.0,216.0,217.0,218.0,219.0,220.0,222.0,223.0,   LL 15380
     *     224.0,234.0,245.0,258.0,270.0,276.0,218.0,210.0,210.0/         LL 15390
      DATA                T03                /272.2,268.7,265.2,261.7,255.7,  LL 15400
     *     249.7,243.7,237.7,231.7,225.7,219.7,219.2,218.7,218.2,217.7,   LL 15410
     *     217.2,216.7,216.2,215.7,215.2,215.2,215.2,215.2,215.2,215.2,   LL 15420
     *     215.2,217.4,227.8,243.2,258.5,265.7,230.7,210.2,210.0/         LL 15430
      DATA                T04                /287.0,282.0,276.0,271.0,266.0,  LL 15440
     *     260.0,253.0,246.0,239.0,232.0,225.0,225.0,225.0,225.0,225.0,   LL 15450
     *     225.0,225.0,225.0,225.0,225.0,225.0,225.0,225.0,225.0,226.0,   LL 15460
     *     228.0,235.0,247.0,262.0,274.0,277.0,216.0,210.0,210.0/         LL 15470
      DATA                T05                /257.1,259.1,255.9,252.7,247.7,  LL 15480
     *     240.9,234.1,227.3,220.6,217.2,217.2,217.2,217.2,217.2,217.2,   LL 15490
     *     217.2,216.6,216.0,215.4,214.8,214.1,213.6,213.0,212.4,211.8,   LL 15500
     *     211.2,216.0,222.2,234.7,247.0,259.3,245.7,210.0,210.0/         LL 15510
      DATA                T06                /288.1,281.6,275.1,268.7,262.2,  LL 15520
     *     255.7,249.2,242.7,236.2,229.7,223.2,216.8,216.6,216.6,216.6,   LL 15530
     *     216.6,216.6,216.6,216.6,216.6,216.6,217.6,218.6,219.6,220.6,   LL 15540
     *     221.6,226.5,236.5,253.4,264.2,270.6,219.7,210.0,210.0/         LL 15550
C                                                                         LL 15560
C                                                                         LL 15570
C                                                                         LL 15580
C     DATA   T07 /34*0.0/                                                 LL 15590
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C                                                                       LL 15600
C                                                                       LL 15610
C *** WATER VAPOR DENSITY (GM.M-3) AT LEVEL I FOR THE MODEL ATMOSPHERES LL 15620
C                                                                       LL 15630
      DATA                WH01                /1.9E+01,1.3E+01,9.3E+00, LL 15640
     *   4.7E+00,2.2E+00,1.5E+00,8.5E-01,4.7E-01,2.5E-01,1.2E-01,      LL 15650
     *   5.0E-02,1.7E-02,6.0E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,      LL 15660
     *   5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,      LL 15670
     *   6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,      LL 15680
     *  1.4E-07,1.0E-09,0.0E+00/                                       LL 15690
      DATA                WH02                /1.4E+01,9.3E+00,5.9E+00, LL 15700
     *   3.3E+00,1.9E+00,1.0E+00,6.1E-01,3.7E-01,2.1E-01,1.2E-01,      LL 15710
     *   6.4E-02,2.2E-02,6.0E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,      LL 15720
     *   5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,      LL 15730
     *   6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,      LL 15740
     *   1.4E-07,1.0E-09,0.0E+00/                                      LL 15750
      DATA                WH03                /3.5E+00,2.5E+00,1.8E+00, LL 15760
     *   1.2E+00,6.6E-01,3.8E-01,2.1E-01,8.5E-02,3.5E-02,1.6E-02,      LL 15770
     *   7.5E-03,6.9E-03,6.0E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,      LL 15780
     *   5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,      LL 15790
     *   6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,      LL 15800
     *   1.4E-07,1.0E-09,0.0E+00/                                      LL 15810
      DATA                WH04                /9.1E+00,6.0E+00,4.2E+00, LL 15820
     *   2.7E+00,1.7E+00,1.0E+00,5.4E-01,2.9E-01,1.3E-01,4.2E-02,      LL 15830
     *   1.5E-02,9.4E-03,6.0E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,      LL 15840
     *   5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,      LL 15850
     *   6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,      LL 15860
     *   1.4E-07,1.0E-09,0.0E+00/                                      LL 15870
      DATA                WH05                /1.2E+00,1.2E+00,9.4E-01, LL 15880
     *   6.8E-01,4.1E-01,2.0E-01,9.8E-02,5.4E-02,1.1E-02,8.4E-03,      LL 15890
     *   5.5E-03,3.8E-03,2.6E-03,1.8E-03,1.0E-03,7.6E-04,6.4E-04,      LL 15900
     *   5.6E-04,5.0E-04,4.9E-04,4.5E-04,5.1E-04,5.1E-04,5.4E-04,      LL 15910
     *   6.0E-04,6.7E-04,3.6E-04,1.1E-04,4.3E-05,1.9E-05,6.3E-06,      LL 15920
     *   1.4E-07,1.0E-09,0.0E+00/                                      LL 15930
      DATA                WH06                /5.9E+00,4.2E+00,2.9E+00, LL 15940
     *   1.8E+00,1.1E+00,6.4E-01,3.8E-01,2.1E-01,1.2E-01,4.6E-02,      LL 15950
     *   1.8E-02,8.2E-03,3.7E-03,1.8E-03,8.4E-04,7.2E-04,6.1E-04,      LL 15960
     *   5.2E-04,4.4E-04,4.4E-04,4.4E-04,4.8E-04,5.2E-04,5.7E-04,      LL 15970
     *   6.1E-04,6.6E-04,3.8E-04,1.6E-04,6.7E-05,3.2E-05,1.2E-05,      LL 15980
     *   1.5E-07,1.0E-09,0.0E+00/                                      LL 15990
C                                                                       LL 16000
C                                                                       LL 16010
C     DATA   WH07 /34*0.0/                                              LL 16020
C                                                                       LL 16030
C                                                                       LL 16040
C                                                                       LL 16050
C *** OZONE DENSITY (GM.M-3) AT LEVEL I FOR THE MODEL ATMOSPHERES       LL 16060
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C
      DATA                W001                /5.6E-05,5.6E-05,5.4E-05,
     *   5.1E-05,4.7E-05,4.5E-05,4.3E-05,4.1E-05,3.9E-05,3.9E-05,
     *   3.9E-05,4.1E-05,4.3E-05,4.5E-05,4.5E-05,4.7E-05,4.7E-05,
     *   6.9E-05,9.0E-05,1.4E-04,1.9E-04,2.4E-04,2.8E-04,3.2E-04,
     *   3.4E-04,3.4E-04,2.4E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,
     *   8.6E-08,4.3E-11,0.0E+00/
      DATA                W002                /6.0E-05,6.0E-05,6.0E-05,
     *   6.2E-05,6.4E-05,6.6E-05,6.9E-05,7.5E-05,7.9E-05,8.6E-05,
     *   9.0E-05,1.1E-04,1.2E-04,1.5E-04,1.8E-04,1.9E-04,2.1E-04,
     *   2.4E-04,2.8E-04,3.2E-04,3.4E-04,3.6E-04,3.6E-04,3.4E-04,
     *   3.2E-04,3.0E-04,2.0E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,
     *   8.6E-06,4.3E-11,0.0E+00/
      DATA                W003                /6.0E-05,5.4E-05,4.9E-05,
     *   4.9E-05,4.9E-05,5.8E-05,6.4E-05,7.7E-05,9.0E-05,1.2E-04,
     *   1.6E-04,2.1E-04,2.6E-04,3.0E-04,3.2E-04,3.4E-04,3.6E-04,
     *   3.9E-04,4.1E-04,4.3E-04,4.5E-04,4.3E-04,4.3E-04,3.9E-04,
     *   3.6E-04,3.4E-04,1.9E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,
     *   8.6E-08,4.3E-11,0.0E+00/
      DATA                W004                /4.9E-05,5.4E-05,5.6E-05,
     *   5.8E-05,6.0E-05,6.4E-05,7.1E-05,7.5E-05,7.9E-05,1.1E-04,
     *   4.3E-04,1.8E-04,2.1E-04,2.6E-04,2.8E-04,3.2E-04,3.4E-04,
     *   3.9E-04,4.1E-04,4.1E-04,3.9E-04,3.6E-04,3.2E-04,3.0E-04,
     *   2.8E-04,2.6E-04,1.4E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,
     *   8.6E-08,4.3E-11,0.0E+00/
      DATA                W005                /4.1E-05,4.1E-05,4.1E-05,
     *   4.3E-05,4.5E-05,4.7E-05,4.9E-05,7.1E-05,9.0E-05,1.6E-04,
     *   2.4E-04,3.2E-04,4.3E-04,4.7E-04,4.9E-04,5.6E-04,6.2E-04,
     *   6.2E-04,6.2E-04,6.0E-04,5.6E-04,5.1E-04,4.7E-04,4.3E-04,
     *   3.6E-04,3.2E-04,1.5E-04,9.2E-05,4.1E-05,1.3E-05,4.3E-06,
     *   8.6E-08,4.3E-11,0.0E+00/
      DATA                W006                /5.4E-05,5.4E-05,5.4E-05,
     *   5.0E-05,4.6E-05,4.6E-05,4.5E-05,4.9E-05,5.2E-05,7.1E-05,
     *   9.0E-05,1.3E-04,1.6E-04,1.7E-04,1.9E-04,2.1E-04,2.4E-04,
     *   2.8E-04,3.2E-04,3.5E-04,3.8E-04,3.8E-04,3.9E-04,3.8E-04,
     *   3.6E-04,3.4E-04,2.0E-04,1.1E-04,4.9E-05,1.7E-05,4.0E-06,
     *   8.6E-08,4.3E-11,0.0E+00/
C
C
C     DATA   W007 /34*0.0/
C
C
C *** SPECTRAL DATA'  AEROSOLS
C
C *** AVERAGE CONTINENTAL AEROSCL MODEL
C
      DATA     VX01                          /0.20,0.25,0.31,0.34,0.49,
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     *        0.51, 0.63, 0.69, 0.86, 1.06, 1.54, 2.00, 2.50, 2.70, 3.00,LL 16540
     *        3.20, 3.39, 3.50, 3.75, 4.00, 4.50, 5.50, 6.00, 6.50, 7.20,LL 16550
     *        7.90, 8.20, 8.50, 8.70, 9.00, 9.20, 9.50,10.00,10.59,11.00,LL 16560
     *       13.00,14.80,15.00,17.20,18.50,20.00,25.00,27.90,30.00, 0.00/LL 16570
C                                                                        LL 16580
C *** RURAL AEROSOL MODEL                                                LL 16590
C                                                                        LL 16600
      DATA   VX02                              /0.20, 0.25, 0.30, 0.40, 0.48,LL 16610
     *        0.55, 0.69, 0.86, 1.06, 1.54, 1.80, 2.00, 2.50, 3.00, 3.50,LL 16620
     *        3.75, 4.00, 5.00, 5.50, 6.00, 7.20, 7.90, 8.20, 8.50, 8.70,LL 16630
     *        9.00, 9.20, 9.50, 9.80,10.00,10.59,11.00,11.50,12.50,13.00,LL 16640
     *       14.00,15.00,16.40,17.20,18.50,20.00,22.50,25.00,30.00, 0.00/LL 16650
C                                                                        LL 16660
C *** URBAN AEROSOL MODEL                                                LL 16670
C                                                                        LL 16680
      DATA   VX03                              /0.20, 0.25, 0.30, 0.40, 0.49,LL 16690
     *        0.55, 0.69, 0.86, 1.06, 1.54, 1.80, 2.00, 2.50, 3.00, 3.50,LL 16700
     *        3.75, 4.00, 5.00, 5.50, 6.00, 7.20, 7.90, 8.20, 8.50, 8.70,LL 16710
     *        9.00, 9.20, 9.50, 9.80,10.00,10.59,11.00,11.50,12.50,13.00,LL 16720
     *       14.00,15.00,16.40,17.20,18.50,20.00,22.50,25.00,30.00, 0.00/LL 16730
C                                                                        LL 16740
C *** MARITIME AEROSCI MODEL                                             LL 16750
C                                                                        LL 16760
      DATA   VX04                              /0.20, 0.25, 0.30, 0.40, 0.49,LL 16770
     *        0.55, 0.69, 0.86, 1.06, 1.54, 1.80, 2.00, 2.50, 3.00, 3.50,LL 16780
     *        3.75, 4.00, 5.00, 5.50, 6.00, 7.20, 7.90, 8.20, 8.50, 8.70,LL 16790
     *        9.00, 9.20, 9.50, 9.80,10.00,10.59,11.00,11.50,12.50,13.00,LL 16800
     *       14.00,15.00,16.40,17.20,18.50,20.00,22.50,25.00,30.0, 0.00/ LL 16810
C                                                                        LL 16820
C *** TRANSMITTANCE FUNCTIONS                                            LL 16830
C                                                                        LL 16840
      DATA                TR /0.999,0.998,0.996,0.994,0.992,0.990,0.980,   LL 16850
     *   0.970,0.960,0.950,0.940,0.930,0.920,0.910,0.900,0.880,0.860,      LL 16860
     *   0.840,0.820,0.800,0.780,0.760,0.740,0.720,0.700,0.680,0.660,      LL 16870
     *   0.640,0.620,0.600,0.580,0.560,0.540,0.520,0.500,0.480,0.460,      LL 16880
     *   0.440,0.420,0.400,0.380,0.360,0.340,0.320,0.300,0.280,0.260,      LL 16890
     *   0.240,0.220,0.200,0.180,0.160,0.140,0.120,0.100,0.080,0.060,      LL 16900
     *   0.040,0.030,0.020,0.015,0.010,0.008,0.006,0.004,0.002,0.001/      LL 16910
C                                                                        LL 16920
C *** TRANSMITTANCE FUNCTION FOR H2O                                     LL 16930
C                                                                        LL 16940
      DATA                FW       /-2.3468,-2.0362,-1.6990,-1.4815,-1.3279,LL 16950
     *  -1.2007,-0.7825,-0.5229,-0.3468,-0.1938, 0.0655, 0.0414, 0.1553,LL 16960
     *   0.2430, 0.3324, 0.4342, 0.6128, 0.7243, 0.8261, 0.9191, 1.0000,LL 16970
     *   1.0792, 1.1461, 1.2122, 1.2672, 1.3284, 1.3892, 1.4409, 1.4955,LL 16980
     *   1.5441, 1.5966, 1.6435, 1.6857, 1.7340, 1.7782, 1.8261, 1.8692,LL 16990
     *   1.9191, 1.9638, 2.0086, 2.0607, 2.1038, 2.1461, 2.1875, 2.2304,LL 17000
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     *   2.2788, 2.3263, 2.3717, 2.4183, 2.4698, 2.5159, 2.5740, 2.6284,LL 17010
     *   2.6952, 2.7559, 2.8261, 2.9031, 3.0000, 3.0607, 3.1461, 3.2041,LL 17020
     *   3.2718, 3.3054, 3.3444, 3.3979, 3.4914, 3.5682/                LL 17030
C                                                                       LL 17040
C *** TRANSMITTANCE FUNCTION FOR OZONE                                  LL 17050
C                                                                       LL 17060
      DATA              FO      /-1.6778,-1.3980,-1.1192,-0.9508,-0.8239,LL 17070
     *  -0.7258,-0.4318,-0.2366,-0.1074,-0.0000, 0.0969, 0.1761, 0.2304,LL 17080
     *   0.3010, 0.3522, 0.4624, 0.5563, 0.6435, 0.7243, 0.7924, 0.8573,LL 17090
     *   0.9191, 0.9731, 1.0253, 1.0719, 1.1173, 1.1614, 1.2095, 1.2480,LL 17100
     *   1.2900, 1.3263, 1.3617, 1.3979, 1.4393, 1.4698, 1.4983, 1.5314,LL 17110
     *   1.5682, 1.6021, 1.6335, 1.6721, 1.7076, 1.7482, 1.7924, 1.8325,LL 17120
     *   1.8865, 1.9395, 2.0000, 2.0607, 2.1206, 2.1903, 2.2552, 2.3385,LL 17130
     *   2.4313, 2.5185, 2.6435, 2.7853, 2.9777, 3.1072, 3.2553, 3.3617,LL 17140
     *   3.4771, 3.5563, 3.6233, 3.7076, 3.8325, 3.9345/                LL 17150
C                                                                       LL 17160
C *** SPECTRAL DATA' H2O                                                LL 17170
C                                                                       LL 17180
      DATA      C101                                                    LL 17190
     *  / 3.93, 3.72, 3.54, 3.42, 3.37, 3.37, 3.36, 3.33, 3.25, 3.13,   LL 17200
     *    3.02, 2.96, 2.97, 3.00, 3.08, 3.12, 3.08, 3.03, 3.00, 3.01,   LL 17210
     *    3.03, 3.07, 3.05, 3.01, 2.94, 2.83, 2.71, 2.62, 2.58, 2.57,   LL 17220
     *    2.62, 2.67, 2.72, 2.71, 2.60, 2.46, 2.35, 2.26, 2.22, 2.23,   LL 17230
     *    2.19, 2.17, 2.17, 2.20, 2.26, 2.34, 2.42, 2.39, 2.20, 2.01,   LL 17240
     *    1.92, 1.83, 1.78, 1.79, 1.81, 1.84, 1.83, 1.80, 1.71, 1.51,   LL 17250
     *    1.39, 1.30, 1.25, 1.18, 1.19, 1.18, 1.21, 1.33, 1.47, 1.53,   LL 17260
     *    1.54, 1.36, 1.12, 0.89, 0.69, 0.49, 0.60, 0.71, 0.79, 0.99,   LL 17270
     *    0.86, 0.73, 0.53, 0.43, 0.51, 0.52, 0.67, 0.73, 0.80, 0.83,   LL 17280
     *    0.80, 0.63, 0.47, 0.32,-0.08,-0.21,-0.29,-0.21,-0.01, 0.08,   LL 17290
     *    0.16, 0.09,-0.03,-0.21,-0.37,-0.35,-0.30,-0.31,-0.37,-0.42,   LL 17300
     *   -0.48,-0.42,-0.40,-0.39,-0.43,-0.77,-0.83,-0.88,-0.79,-0.60,   LL 17310
     *   -0.50,-0.42,-0.39,-0.38,-0.37,-0.40,-0.51,-0.67,-0.82,-0.58,   LL 17320
     *   -0.40,-0.32,-0.21,-0.09,-0.18,-0.16,-0.19,-0.28,-0.33,-0.35,   LL 17330
     *   -0.28,-0.22,-0.10,-0.05,-0.11,-0.13,-0.27,-0.27,-0.18,-0.06,   LL 17340
     *    0.11, 0.23, 0.26, 0.19, 0.11,-0.00,-0.09, 0.02, 0.08, 0.12,   LL 17350
     *    0.22, 0.28, 0.39, 0.54, 0.68, 0.75, 0.79, 0.79, 0.71, 0.69,   LL 17360
     *    0.76, 0.88, 1.01, 1.16, 1.18, 1.14, 1.05, 1.02, 1.11, 1.23,   LL 17370
     *    1.41, 1.75, 1.83, 1.99, 2.05, 2.03, 2.00, 1.96, 1.90, 1.86/   LL 17380
C                                                                       LL 17390
      DATA      C102                                                    LL 17400
     *  / 1.91, 2.08, 2.24, 2.41, 2.63, 2.68, 2.67, 2.73, 2.79, 2.81,   LL 17410
     *    2.91, 2.93, 3.02, 3.16, 3.23, 3.30, 3.34, 3.43, 3.57, 3.59,   LL 17420
     *    3.59, 3.58, 3.57, 3.61, 3.71, 3.71, 3.69, 3.64, 3.60, 3.68,   LL 17430
     *    3.80, 3.95, 4.05, 4.05, 4.02, 3.99, 3.96, 4.01, 4.13, 4.22,   LL 17440
     *    4.35, 4.40, 4.58, 4.62, 4.63, 4.61, 4.57, 4.56, 4.56, 4.53,   LL 17450
     *    4.49, 4.48, 4.40, 4.20, 4.14, 3.92, 3.63, 3.35, 3.16, 3.10,   LL 17460
     *    3.24, 3.47, 3.66, 3.80, 3.93, 4.00, 4.04, 4.15, 4.23, 4.31,   LL 17470
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*     4.35,  4.31,  4.23,  4.20,  4.24,  4.28,  4.35,  4.42,  4.42,  4.44,    LL 17480
*     4.46,  4.40,  4.30,  4.22,  4.13,  4.07,  4.12,  4.19,  4.22,  4.23,    LL 17490
*     4.16,  4.04,  3.99,  3.94,  3.93,  3.91,  3.86,  3.83,  3.80,  3.78,    LL 17500
*     3.70,  3.54,  3.40,  3.30,  3.31,  3.42,  3.52,  3.52,  3.49,  3.41,    LL 17510
*     3.21,  3.14,  3.10,  3.08,  3.11,  2.98,  2.88,  2.78,  2.74,  2.76,    LL 17520
*     2.72,  2.76,  2.82,  2.85,  2.86,  2.75,  2.64,  2.60,  2.61,  2.64,    LL 17530
*     2.56,  2.49,  2.37,  2.25,  2.14,  2.08,  2.11,  2.20,  2.31,  2.28,    LL 17540
*     2.15,  2.06,  1.98,  2.03,  2.05,  1.96,  1.84,  1.72,  1.64,  1.59,    LL 17550
*     1.57,  1.57,  1.60,  1.63,  1.51,  1.38,  1.07,  0.91,  0.87,  0.92,    LL 17560
*     1.04,  1.01,  0.92,  0.84,  0.92,  0.97,  1.01,  1.06,  1.10,  1.06,    LL 17570
*     1.01,  0.91,  0.79,  0.55,  0.47,  0.41,  0.39,  0.38,  0.34,  0.33,    LL 17580
*     0.36,  0.43,  0.48,  0.45,  0.38,  0.27,  0.21,  0.22,  0.29,  0.37/    LL 17590
C                                                                             LL 17600
 DATA      C103                                                               LL 17610
*   / 0.38,  0.37,  0.29,  0.19,  0.13,  0.11,  0.03,-0.05,-0.12,-0.24,      LL 17620
*    -0.31,-0.39,-0.43,-0.50,-0.59,-0.68,-0.73,-0.80,-0.92,-1.06,            LL 17630
*    -1.14,-1.22,-1.27,-1.28,-1.33,-1.32,-1.43,-1.51,-1.63,-1.74,            LL 17640
*    -1.82,-1.98,-2.09,-2.21,-2.21,-2.24,-2.27,-2.36,-2.51,-2.65,            LL 17650
*    -2.70,-2.63,-2.57,-2.56,-2.59,-2.67,-2.69,-2.67,-2.68,-2.62,            LL 17660
*    -2.52,-2.42,-2.29,-2.14,-2.00,-1.87,-1.71,-1.51,-1.39,-1.27,            LL 17670
*    -1.12,-1.01,-0.89,-0.75,-0.68,-0.57,-0.47,-0.42,-0.32,-0.27,            LL 17680
*    -0.26,-0.19,-0.13,-0.11,-0.01,  0.05,  0.08,  0.17,  0.25,  0.31,       LL 17690
*     0.41,  0.43,  0.44,  0.43,  0.36,  0.35,  0.31,  0.25,  0.25,  0.22,    LL 17700
*     0.21,  0.33,  0.49,  0.65,  0.76,  0.71,  0.51,  0.30,  0.13,  0.10,    LL 17710
*     0.17,  0.24,  0.31,  0.38,  0.45,  0.51,  0.56,  0.60,  0.63,  0.62,    LL 17720
*     0.63,  0.64,  0.66,  0.69,  0.76,  0.75,  0.74,  0.70,  0.62,  0.53,    LL 17730
*     0.46,  0.39,  0.38,  0.37,  0.38,  0.42,  0.47,  0.50,  0.58,  0.69,    LL 17740
*     0.67,  0.62,  0.64,  0.68,  0.76,  0.90,  1.11,  1.13,  1.10,  0.97,    LL 17750
*     0.98,  1.17,  1.38,  1.52,  1.70,  1.76,  1.84,  1.92,  1.90,  1.87,    LL 17760
*     1.91,  2.02,  2.13,  2.10,  2.18,  2.22,  2.25,  2.03,  2.01,  1.77,    LL 17770
*     1.93,  2.19,  2.28,  2.14,  2.15,  2.22,  2.01,  2.14,  2.26,  2.36,    LL 17780
*     2.51,  2.66,  2.73,  2.68,  2.69,  2.64,  2.22,  1.95,  1.61,  1.11,    LL 17790
*     0.88,  0.83,  0.89,  1.20,  1.62,  1.82,  1.99,  2.01,  2.14,  2.16/    LL 17800
C                                                                             LL 17810
 DATA      C104                                                               LL 17820
*   / 2.21,  2.30,  2.33,  2.42,  2.50,  2.51,  2.49,  2.46,  2.42,  2.37,    LL 17830
*     2.37,  2.33,  2.31,  2.43,  2.56,  2.61,  2.63,  2.60,  2.50,  2.38,    LL 17840
*     2.41,  2.34,  2.31,  2.32,  2.40,  2.27,  2.32,  2.22,  2.09,  2.08,    LL 17850
*     2.17,  2.41,  2.77,  2.68,  2.49,  2.29,  2.23,  2.42,  2.61,  2.58,    LL 17860
*     2.49,  2.40,  2.39,  2.51,  2.60,  2.68,  2.68,  2.70,  2.82,  2.83,    LL 17870
*     2.82,  2.81,  2.84,  2.86,  2.91,  2.96,  3.03,  3.08,  3.21,  3.30,    LL 17880
*     3.40,  3.52,  3.49,  3.46,  3.51,  3.54,  3.56,  3.55,  3.57,  3.61,    LL 17890
*     3.71,  3.80,  3.92,  3.99,  4.06,  4.02,  4.06,  4.12,  4.28,  4.30,    LL 17900
*     4.22,  4.32,  4.42,  4.53,  4.64,  4.55,  4.40,  4.28,  4.32,  4.38,    LL 17910
*     4.37,  4.24,  4.13,  4.14,  4.20,  4.25,  4.32,  4.35,  4.31,  4.27,    LL 17920
*     4.25,  4.27,  4.31,  4.36,  4.41,  4.52,  4.59,  4.71,  4.79,  4.81,    LL 17930
*     4.73,  4.61,  4.42,  4.28,  4.08,  4.00,  3.88,  3.86,  3.92,  3.98,    LL 17940
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*     4.12,  4.18,  4.31,  4.37,  4.42,  4.50,  4.53,  4.58,  4.59,  4.61,    LL 17950
*     4.61,  4.59,  4.53,  4.49,  4.44,  4.41,  4.40,  4.34,  4.30,  4.26,    LL 17960
*     4.09,  3.98,  3.87,  3.78,  3.77,  3.79,  3.75,  3.72,  3.62,  3.56,    LL 17970
*     3.51,  3.48,  3.32,  3.18,  3.07,  2.96,  2.87,  2.80,  2.68,  2.58,    LL 17980
*     2.59,  2.51,  2.59,  2.57,  2.50,  2.42,  2.32,  2.20,  2.12,  2.00,    LL 17990
*     1.92,  1.79,  1.63,  1.60,  1.69,  1.78,  2.04,  2.00,  1.81,  1.70,    LL 18000
*     1.63,  1.61,  1.60,  1.49,  1.14,  1.35,  1.64,  1.69,  1.70,  1.59/    LL 18010
C                                                                             LL 18020
 DATA      C105                                                               LL 18030
*   / 1.45,  1.29,  1.19,  1.08,  1.02,  1.04,  1.10,  1.16,  1.20,  1.23,    LL 18040
*     1.22,  1.08,  1.08,  1.06,  0.89,  0.93,  0.73,  0.58,  0.54,  0.77,    LL 18050
*     0.81,  0.74,  0.71,  0.57,  0.49,  0.43,  0.38,  0.12,  0.10,  0.20,    LL 18060
*     0.41,  0.37,  0.31,  0.11, -0.13, -0.21, -0.32, -0.36, -0.39, -0.33,    LL 18070
*    -0.39, -0.45, -0.50, -0.56, -0.62, -0.68, -0.77, -0.84, -0.91, -1.00,    LL 18080
*    -1.11, -1.19, -1.28, -1.31, -1.39, -1.43, -1.48, -1.52, -1.57, -1.60,    LL 18090
*    -1.61, -1.60, -1.58, -1.51, -1.42, -1.32, -1.26, -1.16, -1.00, -0.83,    LL 18100
*    -0.71, -0.61, -0.52, -0.43, -0.36, -0.30, -0.21, -0.19, -0.17, -0.15,    LL 18110
*    -0.13, -0.17, -0.19, -0.12, -0.06, -0.01,  0.00, -0.11, -0.23, -0.32,    LL 18120
*    -0.44, -0.51, -0.48, -0.47, -0.42, -0.40, -0.40, -0.39, -0.37, -0.35,    LL 18130
*    -0.48, -0.75, -1.13, -1.58, -1.80, -1.66, -1.52, -1.35, -1.19, -1.02,    LL 18140
*    -0.88, -0.66, -0.65, -0.63, -0.62, -0.66, -0.73, -0.79, -0.88, -0.84,    LL 18150
*    -0.70, -0.59, -0.43, -0.39, -0.50, -0.61, -0.74, -0.79, -0.76, -0.69,    LL 18160
*    -0.62, -0.59, -0.52, -0.48, -0.48, -0.42, -0.39, -0.38, -0.33, -0.29,    LL 18170
*    -0.26, -0.23, -0.22, -0.28, -0.37, -0.50, -0.60, -0.60, -0.51, -0.46,    LL 18180
*    -0.42, -0.43, -0.45, -0.35, -0.24, -0.14, -0.08, -0.08,  0.00,  0.11,    LL 18190
*     0.32,  0.43,  0.42,  0.32,  0.23,  0.22,  0.28,  0.45,  0.55,  0.62,    LL 18200
*     0.65,  0.71,  0.75,  0.80,  0.83,  0.85,  0.87,  0.90,  0.93,  1.00,    LL 18210
*     1.04,  1.15,  1.22,  1.32,  1.31,  1.32,  1.33,  1.48,  1.78,  1.87/    LL 18220
C                                                                             LL 18230
 DATA      C106                                                               LL 18240
*   / 2.01,  1.92,  1.86,  1.89,  1.92,  1.98,  2.03,  2.39,  2.31,  2.48,    LL 18250
*     2.70,  2.71,  2.76,  2.78,  2.70,  2.77,  3.08,  2.94,  3.05,  2.94,    LL 18260
*     3.23,  3.20,  3.19,  3.32,  3.11,  3.41,  3.31,  3.36,  3.46,  3.36,    LL 18270
*     3.39,  3.50,  3.41,  3.22,  3.19,  2.98,  2.78,  2.98,  3.02,  2.82,    LL 18280
*     2.98,  2.86,  2.92,  2.92,  3.05,  3.22,  3.60,  3.78,  3.81,  3.96,    LL 18290
*     3.76,  3.62,  3.34,  3.08,  3.31,  3.16,  3.37,  3.41,  3.30,  3.33,    LL 18300
*     3.33,  3.51,  3.48,  3.43,  3.52,  3.31,  3.40,  3.58,  3.61,  3.49,    LL 18310
*     3.46,  3.42,  3.19,  3.18,  3.30,  3.00,  2.99,  3.21,  3.11,  3.14,    LL 18320
*     3.10,  2.72,  2.81,  2.95,  2.69,  2.73,  2.72,  2.47,  2.51,  2.60,    LL 18330
*     2.42,  2.37,  2.73,  1.91,  1.87,  1.81,  1.78,  1.53,  1.51,  1.62,    LL 18340
*     1.59,  1.50,  1.42,  1.32,  1.22,  1.12,  1.08,  1.02,  0.97,  0.92,    LL 18350
*     0.90,  0.87,  0.84,  0.82,  0.79,  0.78,  0.76,  0.75,  0.72,  0.71,    LL 18360
*     0.71,  0.70,  0.69,  0.67,  0.61,  0.59,  0.52,  0.48,  0.41,  0.39,    LL 18370
*     0.38,  0.33,  0.32,  0.30,  0.30,  0.30,  0.29,  0.28,  0.27,  0.26,    LL 18380
*     0.25,  0.23,  0.22,  0.21,  0.20,  0.18,  0.14,  0.13,  0.06,  0.01,    LL 18390
*    -0.03, -0.07, -0.11, -0.16, -0.21, -0.24, -0.29, -0.32, -0.38, -0.41,    LL 18400
*    -0.45, -0.50, -0.54, -0.61, -0.69, -0.76, -0.84, -0.90, -0.97, -1.01,    LL 18410
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     *    -1.10,-1.13,-1.19,-1.22,-1.28,-1.30,-1.33,-1.36,-1.39,-1.43,    LL 18420
     *    -1.48,-1.50,-1.52,-1.57,-1.61,-1.66,-1.70,-1.72,-1.78,-1.81/    LL 18430
C                                                                         LL 18440
      DATA      C107                                                      LL 18450
     *   /-1.89,-1.92,-2.00,-2.08,-2.16,-2.24,-2.31,-2.40,-2.48,-2.54,    LL 18460
     *    -2.61,-2.71,-2.83,-2.95,-3.10,-5.00,50.00,-5.00,-5.00,-5.00,    LL 18470
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18480
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18490
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18500
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18510
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18520
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18530
     *    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18540
     *    -3.78,-3.33,-3.01,-2.82,-2.68,-2.49,-2.30,-2.13,-2.00,-1.81,    LL 18550
     *    -1.60,-1.41,-1.13,-0.90,-0.79,-0.63,-0.48,-0.36,-0.28,-0.16,    LL 18560
     *    -0.06,  0.08,  0.20,  0.28,  0.41,  0.54,  0.69,  0.80,  0.92,  1.04,    LL 18570
     *     1.19,  1.19,  1.01,  0.98,  1.02,  1.19,  1.29,  1.30,  1.29,  1.38,    LL 18580
     *     1.19,  1.39,  1.42,  1.43,  1.70,  1.62,  1.54,  1.41,  1.53,  1.86,    LL 18590
     *     1.96,  1.97,  2.02,  2.01,  1.94,  1.94,  1.83,  2.03,  2.21,  2.42,    LL 18600
     *     2.30,  2.16,  2.02,  2.02,  2.02,  2.13,  1.90,  1.71,  2.01,  1.56,    LL 18610
     *     1.56,  1.51,  1.30,  1.63,  1.64,  1.67,  1.70,  2.22,  2.39,  2.38,    LL 18620
     *     2.30,  1.93,  2.39,  2.49,  2.52,  2.57,  2.21,  2.18,  2.40,  2.41,    LL 18630
     *     2.45,  2.51,  2.23,  2.49,  2.30,  2.61,  2.72,  2.52,  2.63,  2.56/    LL 18640
C                                                                         LL 18650
      DATA      C108                                                      LL 18660
     *   / 2.51,  2.70,  2.62,  2.62,  2.80,  2.74,  2.79,  2.74,  2.70,  2.88,    LL 18670
     *     2.81,  2.72,  2.76,  2.84,  2.92,  2.98,  2.88,  2.88,  3.02,  3.08,    LL 18680
     *     3.26,  3.03,  3.14,  3.28,  3.03,  3.11,  3.15,  3.30,  3.31,  3.22,    LL 18690
     *     3.00,  3.06,  3.34,  3.40,  3.37,  3.32,  3.08,  3.09,  3.09,  3.01,    LL 18700
     *     3.07,  3.07,  3.31,  3.21,  3.31,  3.67,  3.58,  3.79,  3.70,  3.49,    LL 18710
     *     3.39,  3.11,  3.13,  3.01,  3.10,  3.01,  3.18,  3.32,  3.43,  3.35,    LL 18720
     *     3.40,  3.39,  3.39,  3.51,  3.54,  3.42,  3.50,  3.67,  3.59,  3.63,    LL 18730
     *     3.66,  3.48,  3.39,  3.29,  3.31,  3.41,  3.23,  3.32,  3.12,  2.91,    LL 18740
     *     2.91,  2.75,  2.78,  2.72,  2.62,  2.58,  2.32,  2.22,  2.00,  1.97,    LL 18750
     *     1.68,  1.62,  1.64,  1.53,  1.56,  1.51,  1.52,  1.48,  1.42,  1.42,    LL 18760
     *     1.40,  1.41,  1.43,  1.56,  1.52,  1.51,  1.52,  1.39,  1.39,  1.30,    LL 18770
     *     1.09,  1.16,  1.21,  1.20,  1.22,  1.20,  1.18,  1.20,  1.19,  1.17,    LL 18780
     *     1.10,  1.10,  1.09,  1.10,  1.11,  1.04,  0.98,  0.90,  0.86,  0.90,    LL 18790
     *     0.90,  0.90,  0.86,  0.71,  0.79,  0.70,  0.71,  0.67,  0.62,  0.53,    LL 18800
     *     0.42,  0.31,  0.20,  0.01,-0.08,-0.17,-0.26,-0.35,-0.44,-0.53,    LL 18810
     *    -0.63,-0.73,-0.83,-0.93,-1.04,-1.14,-1.24,-1.34,-1.44,-1.54,    LL 18820
     *    -1.64,-1.74,-1.84,-1.94,-2.04,-2.14,-2.24,-2.34,-2.44,-2.54,    LL 18830
     *    -2.64,-2.74,-2.84,-2.94,-3.04,-3.14,-3.24,-3.34,-3.44,-3.54,    LL 18840
     *    -3.64,-3.74,-3.84,-3.94,-4.04,-5.00,-5.00,-5.00,-5.00,-5.00/    LL 18850
C                                                                         LL 18860
      DATA      C109                                                      LL 18870
     *   /-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18880
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*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18890
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18900
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18910
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18920
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18930
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 18940
*    -4.15,-4.06,-3.97,-3.88,-3.79,-3.70,-3.61,-3.52,-3.43,-3.34,    LL 18950
*    -3.25,-3.16,-3.07,-2.98,-2.98,-2.80,-2.71,-2.62,-2.53,-2.44,    LL 18960
*    -2.35,-2.26,-2.18,-2.09,-2.00,-1.91,-1.82,-1.73,-1.64,-1.55,    LL 18970
*    -1.46,-1.37,-1.28,-1.19,-1.10,-1.01,-0.92,-0.83,-0.74,-0.65,    LL 18980
*    -0.56,-0.47,-0.38,-0.29,-0.20,-0.14,-0.09,-0.02, 0.03, 0.10,    LL 18990
*     0.17, 0.22, 0.30, 0.35, 0.41, 0.45, 0.42, 0.40, 0.43, 0.46,    LL 19000
*     0.50, 0.59, 0.71, 0.84, 0.93, 1.01, 1.06, 1.07, 1.02, 1.01,    LL 19010
*     1.12, 1.23, 1.24, 1.28, 1.34, 1.43, 1.52, 1.56, 1.59, 1.56,    LL 19020
*     1.51, 1.61, 1.50, 1.70, 1.82, 1.92, 1.94, 1.89, 1.81, 1.45,    LL 19030
*     1.30, 1.28, 1.43, 1.50, 1.49, 1.55, 1.48, 1.32, 1.39, 1.53,    LL 19040
*     1.82, 2.23, 2.61, 2.51, 2.20, 1.86, 1.61, 1.19, 1.32, 1.52,    LL 19050
*     1.70, 1.90, 2.01, 1.92, 1.91, 2.12, 2.10, 2.01, 2.18, 1.99/    LL 19060
C                                                                    LL 19070
 DATA      C110                                                      LL 19080
*   / 2.11, 2.28, 2.21, 2.13, 2.00, 1.91, 1.92, 1.97, 1.88, 1.91,    LL 19090
*     1.91, 1.92, 1.93, 1.74, 1.61, 1.58, 1.27, 1.20, 1.18, 1.11,    LL 19100
*     0.99, 0.86, 0.71, 0.60, 0.44, 0.31, 0.19, 0.03,-0.07,-0.21,    LL 19110
*    -0.35,-0.49,-0.64,-0.79,-0.94,-1.11,-1.24,-1.41,-1.57,-1.73,    LL 19120
*    -1.91,-2.09,-2.27,-2.45,-2.63,-2.81,-2.99,-3.18,-3.37,-3.56,    LL 19130
*    -3.75,-3.94,-4.13,-4.31,-4.49,-4.66,-4.83,-4.99,-5.14,-5.28,    LL 19140
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.68,-4.26,    LL 19150
*    -3.89,-3.57,-3.32,-3.11,-2.91,-2.89,-2.79,-2.74,-2.63,-2.47,    LL 19160
*    -2.29,-2.20,-2.17,-2.23,-2.27,-2.32,-2.12,-2.08,-2.07,-2.07,    LL 19170
*    -2.07,-1.98,-1.77,-1.70,-1.63,-1.60,-1.59,-1.43,-1.21,-1.15,    LL 19180
*    -1.09,-1.13,-1.29,-1.19,-0.98,-0.93,-0.87,-0.91,-0.88,-0.71,    LL 19190
*    -0.62,-0.59,-0.58,-0.63,-0.58,-0.39,-0.22,-0.14,-0.06,-0.01,    LL 19200
*    -0.01,-0.08,-0.20,-0.16,-0.02, 0.18, 0.32, 0.42, 0.37, 0.23,    LL 19210
*     0.12, 0.15, 0.28, 0.43, 0.59, 0.58, 0.53, 0.44, 0.39, 0.38,    LL 19220
*     0.35, 0.23, 0.26, 0.19, 0.08, 0.10, 0.18, 0.27, 0.38, 0.43,    LL 19230
*     0.32, 0.37, 0.58, 0.64, 0.87, 0.98, 1.00, 1.02, 1.13, 1.08,    LL 19240
*     1.08, 1.16, 1.16, 1.30, 1.41, 1.40, 1.32, 1.32, 1.37, 1.42,    LL 19250
*     1.50, 1.42, 1.38, 1.36, 1.38, 1.49, 1.63, 1.62, 1.62, 1.70,    LL 19260
*     1.68, 1.60, 1.56, 1.56, 1.63, 1.64, 1.56, 1.49, 1.49, 1.52/    LL 19270
C                                                                    LL 19280
 DATA      C111                                                      LL 19290
*   / 1.58, 1.62, 1.62, 1.61, 1.61, 1.62, 1.63, 1.71, 1.72, 1.70,    LL 19300
*     1.70, 1.67, 1.62, 1.66, 1.70, 1.67, 1.56, 1.49, 1.42, 1.38,    LL 19310
*     1.26, 1.20, 1.13, 1.14, 1.19, 1.29, 1.50, 1.72, 1.86, 1.78,    LL 19320
*     1.82, 1.88, 1.82, 1.89, 1.99, 2.00, 2.14, 2.04, 2.02, 2.02,    LL 19330
*     1.98, 1.90, 1.83, 1.81, 1.72, 1.69, 1.59, 1.50, 1.36, 1.20,    LL 19340
*     0.98, 0.63, 0.43, 0.29, 0.16, 0.05, 0.02, 0.03, 0.03, 0.01,    LL 19350
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*    -0.08,-0.18,-0.20,-0.11,-0.06,-0.03,-0.14,-0.21,-0.08,-0.06,    LL 19360
*     0.10, 0.18, 0.11, 0.32, 0.42, 0.44, 0.38, 0.28, 0.42, 0.43,    LL 19370
*     0.41, 0.33, 0.32, 0.41, 0.50, 0.46, 0.31, 0.18, 0.08, 0.20,    LL 19380
*     0.21, 0.34, 0.36, 0.28, 0.35, 0.39, 0.42, 0.38, 0.32, 0.30,    LL 19390
*     0.16,-0.01,-0.23,-0.41,-0.52,-0.48,-0.58,-0.61,-0.48,-0.23,    LL 19400
*    -0.03, 0.21, 0.36, 0.39, 0.47, 0.44, 0.40, 0.51, 0.59, 0.53,    LL 19410
*     0.69, 0.57, 0.48, 0.52, 0.62, 0.59, 0.55, 0.50, 0.32, 0.26,    LL 19420
*     0.11,-0.08,-0.10,-0.16,-0.43,-0.62,-0.88,-1.09,-1.16,-1.31,    LL 19430
*    -1.45,-1.49,-1.78,-1.91,-2.01,-1.97,-1.97,-1.97,-1.97,-2.26,    LL 19440
*    -2.20,-2.01,-1.99,-2.00,-2.04,-2.37,-2.49,-2.44,-2.35,-2.32,    LL 19450
*    -2.19,-2.10,-2.25,-2.16,-2.36,-2.44,-2.40,-2.49,-2.48,-2.43,    LL 19460
*    -2.40,-2.36,-2.40,-2.49,-2.59,-2.68,-2.89,-3.28,-3.51,-3.74,    LL 19470
*    -2.97,-4.20,-4.43,-4.66,-4.89,-5.00,-5.00,-5.00,-5.00,-5.00/    LL 19480
C                                                                    LL 19490
 DATA      C112                                                      LL 19500
*   /-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19510
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19520
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19530
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19540
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 19550
*    -5.00,-5.00,-5.00,-5.00,-5.00,-3.71,-3.56,-3.40,-3.21,-3.06,    LL 19560
*    -2.90,-2.74,-2.60,-2.46,-2.32,-2.17,-2.03,-1.87,-1.79,-1.74,    LL 19570
*    -1.83,-1.82,-1.71,-1.59,-1.49,-1.46,-1.46,-1.49,-1.49,-1.25,    LL 19580
*    -1.24,-1.08,-0.90,-1.06,-0.91,-0.91,-1.01,-0.99,-0.87,-0.92,    LL 19590
*    -0.79,-0.42,-0.54,-0.38,-0.42,-0.48,-0.34,-0.27,-0.17,-0.28,    LL 19600
*    -0.38,-0.22,-0.30,-0.08,-0.01,-0.20, 0.06, 0.10, 0.06, 0.14,    LL 19610
*    -0.12,-0.02,-0.02,-0.13,-0.11,-0.10,-0.06,-0.05,-0.04,-0.10,    LL 19620
*    -0.04,-0.06,-0.21,-0.38,-0.61,-0.40,-0.31,-0.42,-0.58,-0.57,    LL 19630
*    -0.54,-0.24, 0.11, 0.51, 0.81, 0.79, 0.62, 0.26,-0.31,-0.67,    LL 19640
*    -0.80,-0.88,-0.50,-0.39,-0.10, 0.09, 0.06, 0.08, 0.16, 0.21,    LL 19650
*     0.13, 0.32, 0.35, 0.51, 0.60, 0.51, 0.51, 0.40, 0.40, 0.43,    LL 19660
*     0.42, 0.33, 0.43, 0.34, 0.22, 0.13,-0.11,-0.31,-0.31,-0.41,    LL 19670
*    -0.41,-0.39,-0.53,-0.69,-0.84,-0.88,-1.01,-1.10,-1.19,-1.29,    LL 19680
*    -1.45,-1.49,-1.67,-1.67,-1.51,-1.66,-1.60,-1.69,-1.83,-1.51/    LL 19690
C                                                                    LL 19700
 DATA      C113                                                      LL 19710
*   /-1.42,-1.40,-1.24,-1.38,-1.31,-1.30,-1.30,-1.28,-1.39,-1.33,    LL 19720
*    -1.40,-1.35,-1.37,-1.39,-1.41,-1.49,-1.48,-1.56,-1.47,-1.46,    LL 19730
*    -1.41,-1.42,-1.48,-1.41,-1.31,-1.15,-1.13,-1.20,-1.41,-1.88,    LL 19740
*    -2.08,-2.08,-2.22,-2.35,-2.35,-1.98,-1.92,-1.78,-1.57,-1.69,    LL 19750
*    -1.70,-1.70,-1.66,-1.84,-1.50,-1.56,-1.42,-1.29,-1.38,-1.28,    LL 19760
*    -1.48,-1.58,-1.44,-1.53,-1.48,-1.48,-1.58,-1.58,-1.69,-1.79,    LL 19770
*    -2.00,-2.16,-1.99,-2.23,-2.04,-2.04,-2.39,-2.74,-3.09,-3.44,    LL 19780
*    -3.79,-4.14,-4.49,-4.84,-5.19,-2.46,-2.26,-1.99,-2.01,-2.14,    LL 19790
*    -2.31,-2.15,-2.01,-1.99,-2.14,-2.41,-2.12,-1.99,-1.84,-1.79,    LL 19800
*    -1.71,-1.78,-1.72,-1.68,-1.78,-1.52,-1.38,-1.29,-1.22,-0.91,    LL 19810
*    -0.90,-1.01,-0.76,-0.90,-0.90,-0.90,-1.19,-1.00,-0.79,-0.68,    LL 19820
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     *    -0.68,-0.73,-0.85,-0.85,-0.61,-0.61,-0.48,-0.51,-0.92,-0.83,    LL 19830
     *    -0.61,-0.41,-0.29,-0.29,-0.61,-0.74,-0.19,-0.18, 0.00, 0.19,    LL 19840
     *    -0.10, 0.20, 0.20, 0.02, 0.20,-0.01, 0.18, 0.28, 0.11, 0.00,    LL 19850
     *    -0.37,-0.10, 0.02, 0.16, 0.20, 0.00, 0.00, 0.00, 0.00, 0.07,    LL 19860
     *     0.22, 0.11, 0.11, 0.21, 0.09, 0.21, 0.20, 0.37, 0.28, 0.07,    LL 19870
     *     0.09,-0.29,-0.69,-0.69,-0.74,-0.88,-1.01,-0.86,-0.54,-0.19,    LL 19880
     *     0.19, 0.23, 0.21, 0.29, 0.28, 0.29, 0.52, 0.54, 0.51, 0.60,    LL 19890
     *     0.40, 0.49, 0.48, 0.46, 0.49, 0.27, 0.06,-0.33,-0.81,-1.17/    LL 19900
C                                                                         LL 19910
      DATA      C114                                                      LL 19920
     *   /-1.11,-1.37,-1.52,-1.54,-1.94,-2.06,-2.06,-2.14,-1.96,-2.00,    LL 19930
     *    -2.00,-2.08,-2.23,-2.31,-2.31,-2.53,-2.31,-2.31,-2.31,-2.28,    LL 19940
     *    -2.34,-2.34,-1.91,-1.82,-1.69,-1.56,-1.84,-1.91,-1.75,-1.83,    LL 19950
     *    -1.76,-1.54,-1.98,-1.80,-1.68,-1.69,-1.56,-1.60,-1.71,-1.36,    LL 19960
     *    -1.36,-1.44,-1.48,-1.40,-1.48,-1.36,-1.45,-1.49,-1.85,-1.39,    LL 19970
     *    -1.23,-1.18,-1.18,-1.34,-1.36,-1.23,-1.23,-1.37,-1.30,-1.40,    LL 19980
     *    -1.28,-1.27,-1.37,-1.32,-1.32,-1.22,-1.28,-1.38,-1.69,-2.07,    LL 19990
     *    -2.42,-2.58,-2.58,-2.80,-2.58,-2.43,-1.88,-1.60,-1.26,-1.16,    LL 20000
     *    -1.23,-1.10,-1.23,-1.10,-0.83,-0.80,-0.80,-0.80,-0.98,-0.97,    LL 20010
     *    -0.97,-0.91,-0.92,-1.13,-1.24,-1.50,-1.98,-2.18,-2.32,-2.63,    LL 20020
     *    -3.91,-4.20,-4.49,-4.78,-5.07,-5.07,-5.07,-5.07,-5.07,-5.07/    LL 20030
C                                                                         LL 20040
CC *** SPECTRAL DATA'  UNIFORMLY MIXED GASES                              LL 20050
C                                                                         LL 20060
      DATA      C201                                                      LL 20070
     *   /-4.25,-3.70,-3.20,-2.75,-1.90,-1.73,-1.51,-1.29,-1.11,-0.91,    LL 20080
     *    -0.71,-0.51,-0.30,-0.60, 0.22, 0.49, 0.76, 1.08, 1.29, 1.56,    LL 20090
     *     1.76, 1.91, 2.08, 2.23, 2.36, 2.51, 2.72, 2.90, 3.12, 3.37,    LL 20100
     *     3.56, 3.69, 3.79, 3.86, 3.88, 3.86, 3.73, 3.58, 3.38, 3.17,    LL 20110
     *     2.86, 2.73, 2.52, 2.31, 2.17, 2.01, 1.89, 1.77, 1.63, 1.47,    LL 20120
     *     1.21, 0.92, 0.53, 0.23,-0.17,-0.53,-0.74,-0.81,-0.84,-0.88,    LL 20130
     *    -1.00,-1.18,-1.42,-1.61,-1.86,-2.10,-2.29,-2.51,-2.72,-2.91,    LL 20140
     *    -3.14,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20150
     *    -5.00,-2.68,-2.47,-2.19,-1.97,-1.71,-1.50,-1.32,-2.12,-1.13,    LL 20160
     *    -1.09,-1.11,-1.10,-1.09,-1.01,-1.01,-1.11,-1.33,-1.66,-2.13,    LL 20170
     *    -2.51,-2.83,-2.71,-2.39,-2.09,-1.78,-1.59,-1.33,-1.18,-1.01,    LL 20180
     *    -0.96,-0.91,-0.90,-0.87,-0.80,-0.79,-0.86,-1.07,-1.28,-1.69,    LL 20190
     *    -2.11,-2.74,-3.09,-3.50,-3.03,-2.58,-2.23,-1.89,-1.54,-1.28,    LL 20200
     *    -1.13,-1.11,-1.16,-1.20,-1.23,-1.21,-1.17,-1.12,-1.15,-1.19,    LL 20210
     *    -1.20,-1.17,-1.02,-0.89,-0.68,-0.42,-0.24,-0.01, 0.18, 0.40,    LL 20220
     *     0.57, 0.77, 0.96, 1.07, 1.13, 1.11, 1.08, 1.15, 1.27, 1.33,    LL 20230
     *     1.44, 1.40, 1.13, 0.89, 0.63, 0.54, 0.65, 0.78, 0.81, 0.86,    LL 20240
     *     0.82, 0.68, 0.47, 0.14,-0.12,-0.48,-0.92,-1.43,-1.89,-2.32,    LL 20250
     *    -2.81,-5.00,-5.00,-5.00,-3.14,-2.47,-2.00,-1.71,-1.59,-1.61/    LL 20260
C                                                                         LL 20270
      DATA      C202                                                      LL 20280
     *   /-1.69,-1.82,-1.87,-1.90,-1.94,-2.04,-2.10,-2.23,-2.32,-2.48,    LL 20290
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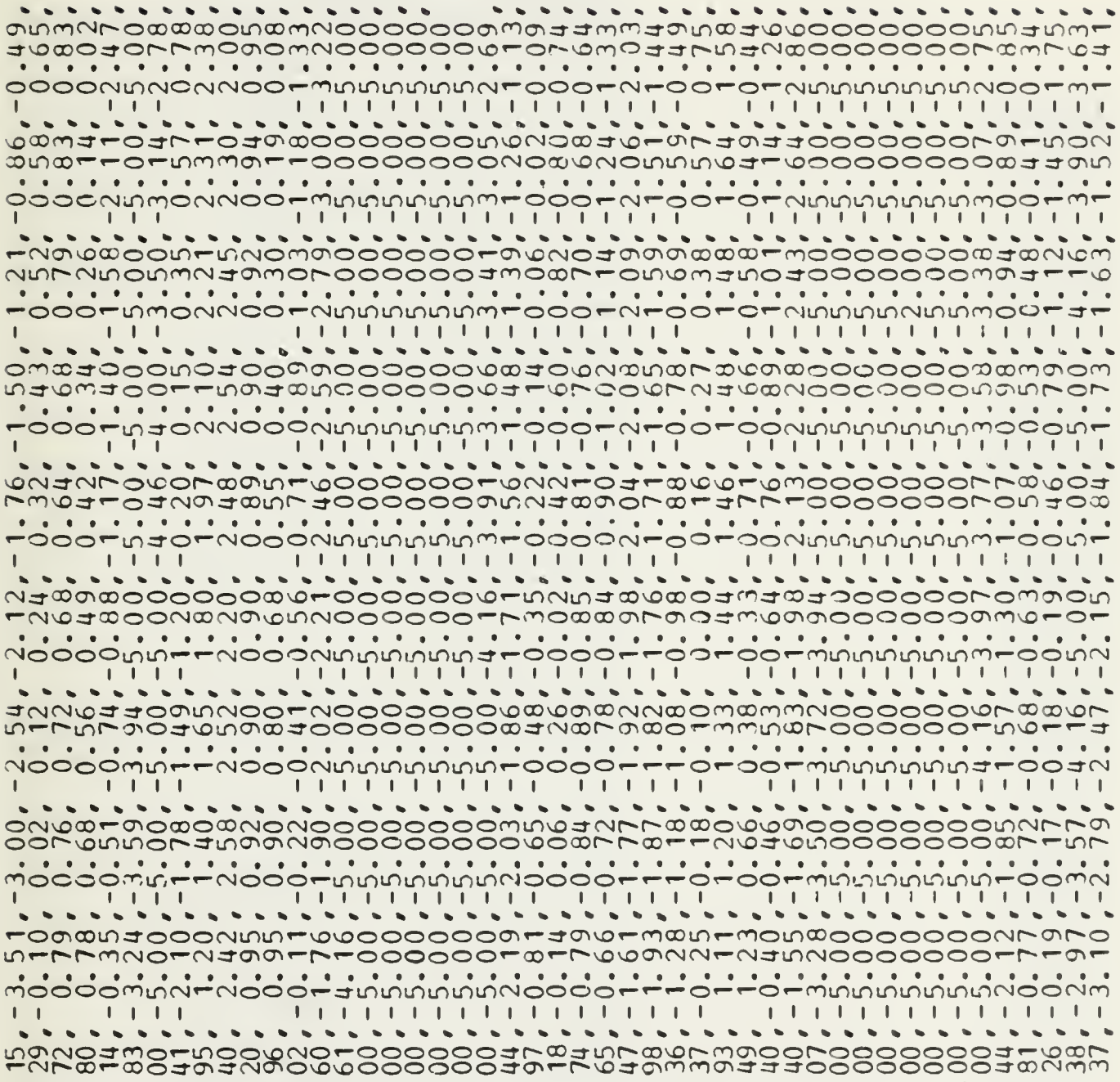
*    -2.71,-2.88,-3.09,-2.99,-2.43,-2.00,-1.69,-1.42,-1.38,-1.49,    LL 20300
*    -1.70,-2.01,-2.41,-2.64,-2.63,-2.49,-2.38,-2.27,-2.16,-2.05,    LL 20310
*    -1.94,-1.83,-1.76,-1.71,-1.70,-1.72,-1.81,-1.92,-2.03,-2.27,    LL 20320
*    -2.61,-3.21,-4.01,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20330
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20340
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20350
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.30,-3.42,-3.17,-2.98,    LL 20360
*    -2.83,-2.71,-2.67,-2.67,-2.68,-2.58,-2.33,-2.01,-1.64,-1.32,    LL 20370
*    -0.97,-0.76,-0.63,-0.59,-0.60,-0.63,-0.69,-0.87,-1.08,-1.26,    LL 20380
*    -1.53,-1.87,-1.91,-1.93,-2.02,-2.21,-2.48,-2.80,-3.08,-3.11,    LL 20390
*    -3.09,-2.93,-2.76,-2.39,-2.01,-1.69,-1.36,-0.99,-0.63,-0.28,    LL 20400
*     0.00, 0.08, 0.11, 0.12, 0.12, 0.07, 0.01,-0.08,-0.23,-0.40,    LL 20410
*    -0.51,-0.53,-0.57,-0.60,-0.61,-0.73,-0.81,-0.95,-1.05,-1.02,    LL 20420
*    -0.91,-0.68,-0.41,-0.09, 0.18, 0.41, 0.76, 1.00, 1.18, 1.39,    LL 20430
*     1.51, 1.58, 1.68, 1.71, 1.80, 1.91, 2.02, 2.18, 2.32, 2.50,    LL 20440
*     2.61, 2.69, 2.81, 2.89, 2.96, 3.04, 3.14, 3.27, 3.41, 3.55,    LL 20450
*     3.72, 3.90, 4.03, 4.22, 4.42, 4.61, 4.71, 4.73, 4.65, 4.63,    LL 20460
*     4.72, 4.78, 4.79, 4.50, 3.62, 3.28, 2.79, 2.30, 1.85, 1.35/    LL 20470
C                                                                    LL 20480
 DATA      C203                                                      LL 20490
*   / 0.62,-0.24,-1.69,-2.18,-2.01,-1.79,-1.53,-1.32,-1.20,-1.15,    LL 20500
*    -1.12,-1.18,-1.25,-1.26,-1.20,-1.17,-1.20,-1.32,-1.54,-1.84,    LL 20510
*    -2.16,-2.30,-2.26,-2.01,-1.71,-1.36,-1.06,-0.81,-0.61,-0.49,    LL 20520
*    -0.45,-0.47,-0.49,-0.46,-0.37,-0.31,-0.34,-0.49,-0.75,-1.11,    LL 20530
*    -1.43,-2.01,-2.60,-2.89,-2.87,-2.74,-2.51,-2.42,-2.38,-2.39,    LL 20540
*    -2.42,-2.46,-2.48,-2.49,-2.43,-2.43,-2.46,-2.53,-2.68,-2.74,    LL 20550
*    -2.82,-2.87,-2.83,-2.82,-2.79,-2.71,-2.66,-2.49,-2.40,-2.32,    LL 20560
*    -2.26,-2.23,-2.20,-2.09,-2.02,-1.96,-1.88,-1.84,-1.86,-1.86,    LL 20570
*    -1.87,-1.83,-1.79,-1.73,-1.68,-1.67,-1.69,-1.74,-1.79,-1.87,    LL 20580
*    -1.78,-1.63,-1.50,-1.37,-1.21,-1.00,-0.83,-0.69,-0.53,-0.41,    LL 20590
*    -0.30,-0.19,-0.09,-0.04, 0.02, 0.10, 0.16, 0.18, 0.23, 0.26,    LL 20600
*     0.27, 0.26, 0.24, 0.22, 0.17, 0.12, 0.07,-0.01,-0.07,-0.09,    LL 20610
*     0.32, 0.72, 0.91, 1.12, 1.03, 0.67, 0.18,-0.11,-0.38,-0.29,    LL 20620
*    -0.17,-0.08,-0.00, 0.09, 0.13, 0.18, 0.24, 0.27, 0.29, 0.30,    LL 20630
*     0.29, 0.26, 0.23, 0.21, 0.13, 0.09, 0.02,-0.04,-0.18,-0.32,    LL 20640
*    -0.51,-0.72,-0.98,-1.18,-1.50,-1.62,-1.81,-2.04,-2.29,-2.49,    LL 20650
*    -2.62,-2.87,-3.03,-3.21,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,    LL 20660
*    -5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.01,-3.38,-3.01,-2.63,    LL 20670
*    -2.32,-2.09,-1.98,-1.94,-2.00,-2.14,-2.26,-2.20,-2.02,-1.82/    LL 20680
C                                                                    LL 20690
 DATA      C204                                                      LL 20700
*   /-1.59,-1.43,-1.38,-1.46,-1.64,-1.90,-2.09,-2.54,-2.91,-3.28,    LL 20710
*    -3.61,-3.72,-3.64,-3.50,-3.41,-3.37,-3.30,-3.16,-3.01,-2.76,    LL 20720
*    -2.51,-2.20,-1.80,-1.49,-1.22,-0.97,-0.72,-0.49,-0.20, 0.03,    LL 20730
*     0.20, 0.36, 0.51, 0.61, 0.67, 0.83, 1.00, 1.22, 1.38, 1.56,    LL 20740
*     1.70, 1.86, 2.01, 2.20, 2.31, 2.47, 2.61, 2.76, 2.92, 3.01,    LL 20750
*     3.05, 3.02, 2.98, 2.98, 3.01, 3.03, 2.97, 2.78, 2.44, 2.13,    LL 20760
```

```
*     1.83,  1.59,  1.49,  1.50,  1.67,  1.84,  2.22,  2.50,  2.71,  2.93,    LL 20770
*     3.12,  3.18,  3.17,  3.15,  3.21,  3.26,  3.19,  2.98,  2.59,  2.14,    LL 20780
*     1.70,  1.22,  0.55, -0.27, -1.09, -2.54, -3.00, -2.94, -2.78, -2.68,    LL 20790
*    -2.61, -2.60, -2.63, -2.60, -2.57, -2.53, -2.57, -2.64, -2.77, -3.04,    LL 20800
*    -3.38, -3.98, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00,    LL 20810
*    -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00,    LL 20820
*    -5.00, -4.00, -3.73, -3.62, -3.59, -3.53, -3.56, -3.57, -3.53, -3.51,    LL 20830
*    -3.45, -3.37, -3.26, -3.21, -3.18, -3.27, -3.36, -3.60, -3.96, -5.00,    LL 20840
*    -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00,    LL 20850
*    -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00,    LL 20860
*    -5.00, -5.00, -5.00, -5.00, -4.62, -4.07, -3.89, -3.76, -3.67, -3.56,    LL 20870
*    -3.42, -3.35, -3.26, -3.18, -3.14, -3.11, -3.09, -3.10, -3.12, -3.23,    LL 20880
*    -3.30, -3.38, -3.37, -3.29, -3.14, -3.08, -3.00, -2.93, -2.89, -2.91/    LL 20890
C                                                                             LL 20900
 DATA      C205                                                               LL 20910
*   /-3.00, -3.08, -3.16, -3.31, -3.48, -3.71, -3.98, -5.00, -5.00, -5.00,    LL 20920
*    -5.00, -4.52, -3.98, -3.69, -3.42, -3.18, -2.95, -2.77, -2.61, -2.48,    LL 20930
*    -2.41, -2.41, -2.40, -2.38, -2.34, -2.27, -2.21, -2.31, -2.48, -2.73,    LL 20940
*    -3.21, -4.13, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00,    LL 20950
*    -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00, -5.00,    LL 20960
*    -5.00, -5.00, -4.13, -4.02, -3.99, -3.96, -3.87, -3.73, -3.51, -3.29,    LL 20970
*    -3.13, -2.99, -2.84, -2.73, -2.69, -2.68, -2.69, -2.65, -2.62, -2.59,    LL 20980
*    -2.57, -2.62, -2.81, -3.04, -3.21, -3.39, -3.42, -3.36, -3.21, -3.03,    LL 20990
*    -2.93, -2.80, -2.64, -2.52, -2.37, -2.28, -2.20, -2.13, -2.07, -2.02,    LL 21000
*    -1.96, -1.88, -1.78, -1.63, -1.44, -1.31, -1.20, -1.08, -0.98, -0.94,    LL 21010
*    -0.86, -0.76, -0.52, -0.31, -0.08,  0.13,  0.30,  0.37,  0.36,  0.36,    LL 21020
*     0.35,  0.35,  0.39,  0.46,  0.48,  0.41,  0.23, -0.08, -0.38, -0.67,    LL 21030
*    -0.88, -0.96, -0.98, -0.87, -0.67, -0.36, -0.12,  0.14,  0.44,  0.68,    LL 21040
*     0.90,  1.11,  1.19,  1.24,  1.25,  1.26,  1.27,  1.51,  1.59,  1.50,    LL 21050
*     1.28,  0.71,  0.11, -0.28, -0.67, -1.32, -1.61, -1.58, -1.42, -1.18,    LL 21060
*    -0.91, -0.59, -0.27, -0.06,  0.29,  0.57,  0.73,  0.92,  0.81,  0.73,    LL 21070
*     0.79,  0.91,  1.01,  1.03,  0.88,  0.72,  0.63,  0.38,  0.12, -0.21,    LL 21080
*    -0.47, -0.67, -1.23, -1.67, -2.31, -2.76, -3.24, -3.49, -3.51, -3.47,    LL 21090
*    -3.39, -3.37, -3.43, -3.53, -3.50, -3.36, -3.18, -3.07, -2.96, -3.08/    LL 21100
 END                                                                          LL 21120
```

# APPENDIX B

## CONTINUED DATA PACKAGE



```
-1.33,-1.25,-1.17,-1.09,-1.02,-0.96,-0.89,-0.82,-0.73,-0.68,
-0.54,-0.42,-0.27,-0.12, 0.03, 0.18, 0.25, 0.31, 0.39, 0.47,
 0.48, 0.49, 0.50, 0.50, 0.48, 0.46, 0.23, 0.01,-0.11,-0.33,
-0.55,-0.77,-0.83,-0.88,-0.94,-0.92,-0.91,-0.90,-0.85,-0.80,
-0.76,-0.71,-0.69,-0.67,-0.66,-0.65,-0.65,-0.66,-0.67,-0.68,
-0.70,-0.72,-0.82,-0.93,-1.03,-1.14,-1.24,-1.34,-1.51,-1.68,
-2.13,-2.57,-2.92,-3.26,-3.71,-4.16,-5.00,-5.00,-5.00,-5.00,
2.93E-04 3.86E-04 5.09E-04 6.56E-04 8.85E-04
1.06E-03,1.31E-03,1.73E-03,2.27E-03,2.73E-03,3.36E-03,3.95E-03,
5.46E-03,7.19E-03,9.00E-03,1.13E-02,1.36E-02,1.66E-02,1.96E-02,
2.16E-02,2.36E-02,2.63E-02,2.90E-02,3.15E-02,3.40E-02,3.66E-02,
3.92E-02,4.26E-02,4.60E-02,4.95E-02,5.30E-02,5.65E-02,6.00E-02,
6.30E-02,6.60E-02,6.89E-02,7.18E-02,7.39E-02,7.60E-02,7.84E-02,
8.08E-02,8.39E-02,8.70E-02,9.13E-02,9.56E-02,1.08E-01,1.20E-01,
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1.11E-01,1.12E-01,1.14E-01,1.13E-01,1.12E-01,1.09E-01,1.07E-01,
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8.00E-03,7.00E-03,6.50E-03,6.00E-03,5.50E-03,4.75E-03,4.00E-03,
3.75E-03,3.50E-03,3.00E-03,2.50E-03,2.25E-03,2.00E-03,1.85E-03,
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1.34E-03,1.25E-03,1.06E-03,9.06E-04,7.53E-04,6.41E-04,5.09E-04,
4.04E-04,3.36E-04,2.86E-04,2.32E-04,1.94E-04,1.57E-04,1.31E-04,
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0.147
0.117
0.097
0.087
0.100
0.120
0.147
0.174
0.200
0.240
0.280
0.330
0.000
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3.82E-02,2.94E-02,2.09E-02,1.80E-02,1.91E-02,1.66E-02,1.03E-01,
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9.75E+01,7.65E+01,6.04E+01,4.62E+01,3.46E+01,2.52E+01,2.00E+01,
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-2.41,-2.27,-2.16,-2.11,-2.28,-2.29,-2.21,-2.06,-1.91,-1.99,
-2.27,-2.59,-2.98,-3.35,-3.69,-3.79,-3.68,-3.53,-3.45,-3.39,
-3.31,-3.18,-2.97,-2.69,-3.39,-2.11,-1.83,-1.58,-1.49,-1.22
-1.08,-0.89,-0.68,-0.54,-0.71,-0.79,-0.78,-0.66,-0.49,-0.54,
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-0.67,-0.57,-0.38,-0.51,-0.97,-1.36,-1.89,-2.74,-3.18,-4.21,
-4.57,-4.62,-4.78,-4.87,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
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-2.18,-2.13,-2.04,-1.78,-1.83,-2.08,-2.28,-2.81,-3.01,-3.15,
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-4.81,-4.52,-4.11,-3.69,-3.09,-2.99,-2.91,-2.89,-3.19,-3.20,
-3.36,-3.62,-3.89,-3.92,-3.73,-3.53,-3.37,-3.19,-3.02,-2.79,
-2.52,-2.36,-2.24,-2.19,-2.32,-2.41,-2.29,-2.06,-2.00,-2.18,
-2.47,-2.91,-3.57,-4.89,-5.00,-5.00,-5.00,-5.00,-5.00,-4.61,
-4.18,-3.89,-3.57,-3.30,-3.02,-2.74,-2.51,-2.20,-1.98,-1.73,
-1.57,-1.38,-1.21,-1.11,-0.98,-0.87,-0.78,-0.60,-0.37,-0.18,
-0.04,-0.04,-0.06,-0.16,-0.18,-0.19,-0.23,-0.45,-1.02,-1.97,
-2.70,-3.71,-4.01,-4.20,-4.35,-4.58,-4.73,-4.81,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-4.71,-4.31,-3.99,-3.68,-3.50,-3.34,-3.22,
-3.23,-3.25,-3.24,-3.18,-3.10,-3.07,-3.18,-3.41,-3.67,-4.12,
-4.68,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.51,-4.18,
-3.73,-3.48,-3.17,-2.96,-2.73,-2.63,-2.58,-2.59,-2.57,-2.49,
-2.42,-2.38,-2.48,-2.62,-3.02,-3.49,-4.16,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.87,-4.50,
-4.21,-3.90,-3.66,-3.56,-3.51,-3.51,-3.51,-3.49,-3.41,-3.34,
-3.34,-3.47,-3.60,-3.87,-4.23,-4.59,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.93,
-4.51,-4.10,-3.78,-3.32,-3.03,-2.74,-2.43,-2.08,-1.83,-1.59,
-1.29,-1.02,-0.81,-0.70,-0.73,-0.90,-1.08,-1.19,-1.35,-1.47,
-1.57,-1.66,-1.80,-1.91,-2.04,-2.18,-2.33,-2.47,-2.61,-2.78,
-2.97,-3.10,-3.28,-3.44,-3.63,-3.81,-3.98,-4.15,-4.32,-4.61,
-4.71,-4.80,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-4.32
-3.24,-2.59,-2.12,-1.82,-1.57,-1.34,-1.16,-1.02,-0.82,-0.64,
-0.48,-0.33,-0.14,-0.06, 0.08, 0.21, 0.39, 0.52, 0.61, 0.72,
 0.85, 0.96, 1.02, 1.12, 1.18, 1.21, 1.17, 1.08, 0.98, 0.90,
 0.97, 1.13, 1.37, 1.58, 1.74, 1.70, 1.48, 1.13, 0.73, 0.22,
-0.51,-1.57,-3.48,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,-5.00,
-5.00,-5.00,-5.00,-5.00,-5.00
```

# APPENDIX C

## SAMPLE OUTPUT

```
SUB-ARCTIC (60 DEG. LAT.) WINTER MODEL ATMOSPH RE
CONTINENTAL AEFCSQL MODEL
HAZE MODEL =  23.0 KM VISLAL RANGE AT SEA LEV L

H1 =   2.500 KM, H2 =   8.500 KM, ANGLE =  65.0000 GEOM. RANGE =  14.15 KM, BETA =  0.11537 DEG

SLANT PATH BETWEEN ALTITUDES H1 AND H2 WHERE H1     2.500 KM H2 =   8.500 KM, ZENITH ANGLE =  65.000 DEGREES
FREQUENCY RANGE V1 =  2350.0 CM-1 TO V2 =  2450.0 CM-1 FOR DV =    5.0 CM-1   (  4.08 -  4.26 MICRONS)
```

HORIZONTAL PROFILES

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0.0 | 1.233E-01 | 1.087E+00 | 1.937E-03 | 8.761E-01 | 6.632E-04 | 1.062E+00 | 1.000E+00 | 1.913E-03 | 2.853E-04 | 2.900E-02 | 3.052E+02 |
| 2 | 1.0 | 1.051E-01 | 8.536E-01 | 1.834E-03 | 6.651E-01 | 6.144E-04 | 9.239E-01 | 4.399E-01 | 1.913E-03 | 2.504E-04 | 2.445E-02 | 2.654E+02 |
| 3 | 2.0 | 7.629E-02 | 6.884E-01 | 1.744E-03 | 5.197E-01 | 4.114E-04 | 8.193E-01 | 1.899E-01 | 1.913E-03 | 2.219E-04 | 1.708E-02 | 2.354E+02 |
| 4 | 3.0 | 4.918E-02 | 5.538E-01 | 1.738E-03 | 4.045E-01 | 2.422E-04 | 7.254E-01 | 7.975E-02 | 2.007E-03 | 1.970E-04 | 1.206E-02 | 2.084E+02 |
| 5 | 4.0 | 2.647E-02 | 4.484E-01 | 1.729E-03 | 3.177E-01 | 1.101E-04 | 6.458E-01 | 4.216E-02 | 2.100E-03 | 1.757E-04 | 7.051E-03 | 1.855E+02 |
| 6 | 5.0 | 1.153E-02 | 3.648E-01 | 1.717E-03 | 2.504E-01 | 3.801E-05 | 5.773E-01 | 3.177E-02 | 2.193E-03 | 1.569E-04 | 3.479E-03 | 1.659E+02 |
| 7 | 6.0 | 5.027E-03 | 2.950E-01 | 1.700E-03 | 1.961E-01 | 1.376E-05 | 5.145E-01 | 2.241E-02 | 2.287E-03 | 1.396E-04 | 1.755E-03 | 1.479E+02 |
| 8 | 7.0 | 2.457E-03 | 2.372E-01 | 2.335E-03 | 1.525E-01 | 6.006E-06 | 4.571E-01 | 2.062E-02 | 3.313E-03 | 1.238E-04 | 9.750E-04 | 1.313E+02 |
| 9 | 8.0 | 4.423E-04 | 1.692E-01 | 2.802E-03 | 1.175E-01 | 8.156E-07 | 4.043E-01 | 2.146E-02 | 4.200E-03 | 1.086E-04 | 2.049E-04 | 1.162E+02 |
| 10 | 9.0 | 2.955E-04 | 1.470E-01 | 4.693E-03 | 8.799E-02 | 5.326E-07 | 3.512E-01 | 2.057E-02 | 7.467E-03 | 9.359E-05 | 1.475E-04 | 1.009E+02 |
| 11 | 10.0 | 1.680E-04 | 1.117E-01 | 6.611E-03 | 6.428E-02 | 2.896E-07 | 3.002E-01 | 2.007E-02 | 1.120E-02 | 8.000E-05 | 8.240E-05 | 8.626E+01 |
| 12 | 11.0 | 1.006E-04 | 8.490E-02 | 8.279E-03 | 4.697E-02 | 1.681E-07 | 2.566E-01 | 1.880E-02 | 1.493E-02 | 6.837E-05 | 4.887E-05 | 7.374E+01 |
| 13 | 12.0 | 5.984E-05 | 6.446E-02 | 1.045E-02 | 3.429E-02 | 9.673E-08 | 2.192E-01 | 1.975E-02 | 2.007E-02 | 5.844E-05 | 2.092E-05 | 6.300E+01 |
| 14 | 13.0 | 3.598E-05 | 4.901E-02 | 1.072E-02 | 2.507E-02 | 5.657E-08 | 1.875E-01 | 1.823E-02 | 2.193E-02 | 4.996E-05 | 1.084E-05 | 5.367E+01 |
| 15 | 14.0 | 1.736E-05 | 3.725E-02 | 1.050E-02 | 1.832E-02 | 2.639E-08 | 1.603E-01 | 1.785E-02 | 2.267E-02 | 4.270E-05 | 7.996E-06 | 4.606E+01 |
| 16 | 15.0 | 1.145E-05 | 2.829E-02 | 1.127E-02 | 1.338E-02 | 1.707E-08 | 1.369E-01 | 1.677E-02 | 2.613E-02 | 3.654E-05 | 5.194E-06 | 3.935E+01 |
| 17 | 16.0 | 8.366E-06 | 2.159E-02 | 1.173E-02 | 9.820E-03 | 1.229E-08 | 1.174E-01 | 1.595E-02 | 2.893E-02 | 3.131E-05 | 3.604E-06 | 3.374E+01 |
| 18 | 17.0 | 6.371E-06 | 1.642E-02 | 1.101E-02 | 7.184E-03 | 9.194E-09 | 1.005E-01 | 1.576E-02 | 2.893E-02 | 2.682E-05 | 2.891E-06 | 2.898E+01 |
| 19 | 18.0 | 4.946E-06 | 1.253E-02 | 1.035E-02 | 5.273E-03 | 7.033E-09 | 8.615E-02 | 1.525E-02 | 2.893E-02 | 2.298E-05 | 2.245E-06 | 2.476E+01 |
| 20 | 19.0 | 4.205E-06 | 9.538E-03 | 9.406E-03 | 3.859E-03 | 5.918E-09 | 7.375E-02 | 1.285E-02 | 2.800E-02 | 1.967E-05 | 1.912E-06 | 2.115E+01 |
| 21 | 20.0 | 3.357E-06 | 7.260E-03 | 8.245E-03 | 2.824E-03 | 4.657E-09 | 6.315E-02 | 9.431E-03 | 2.613E-02 | 1.683E-05 | 1.530E-06 | 1.815E+01 |
| 22 | 21.0 | 3.301E-06 | 5.515E-03 | 7.049E-03 | 2.062E-03 | 4.571E-09 | 5.399E-02 | 6.836E-03 | 2.380E-02 | 1.439E-05 | 1.301E-06 | 1.552E+01 |
| 23 | 22.0 | 2.663E-06 | 4.189E-03 | 6.099E-03 | 1.506E-03 | 3.942E-09 | 4.617E-02 | 5.145E-03 | 2.193E-02 | 1.230E-05 | 1.305E-06 | 1.327E+01 |
| 24 | 23.0 | 2.629E-06 | 3.180E-03 | 5.238E-03 | 1.099E-03 | 3.624E-09 | 3.947E-02 | 3.936E-03 | 2.007E-02 | 1.052E-05 | 1.197E-06 | 1.134E+01 |
| 25 | 24.0 | 2.533E-06 | 2.413E-03 | 4.115E-03 | 8.012E-04 | 3.528E-09 | 3.372E-02 | 3.121E-03 | 1.680E-02 | 8.984E-06 | 1.154E-06 | 9.691E+00 |
| 26 | 25.0 | 2.451E-06 | 1.829E-03 | 3.432E-03 | 5.836E-04 | 3.481E-09 | 2.880E-02 | 2.627E-03 | 1.493E-02 | 5.968E-06 | 1.117E-06 | 8.277E+00 |
| 27 | 30.0 | 6.381E-07 | 4.420E-04 | 1.166E-03 | 1.153E-04 | 8.463E-10 | 1.273E-02 | 7.912E-04 | 7.000E-03 | 2.649E-06 | 2.355E-07 | 3.659E+00 |
| 28 | 35.0 | 9.587E-08 | 1.096E-04 | 5.216E-04 | 2.348E-05 | 1.113E-10 | 5.705E-03 | 2.062E-04 | 4.293E-03 | 1.190E-06 | 2.766E-08 | 1.659E+00 |
| 29 | 40.0 | 1.675E-08 | 2.784E-05 | 1.710E-04 | 4.924E-06 | 2.001E-11 | 2.577E-03 | 5.481E-05 | 1.913E-03 | 5.448E-07 | 3.780E-09 | 7.405E-01 |
| 30 | 45.0 | 4.317E-09 | 7.615E-06 | 4.056E-05 | 1.123E-06 | 4.311E-12 | 1.215E-03 | 1.443E-05 | 6.067E-04 | 2.600E-07 | 6.191E-10 | 3.492E-01 |
| 31 | 50.0 | 7.652E-10 | 2.221E-06 | 1.018E-05 | 2.757E-07 | 7.224E-13 | 5.547E-04 | 3.809E-06 | 2.007E-04 | 9.178E-08 | 8.159E-11 | 1.709E-01 |
| 32 | 70.0 | 1.604E-12 | 2.291E-08 | 7.112E-08 | 1.474E-09 | 1.118E-15 | 4.407E-05 | 1.962E-08 | 4.013E-06 | 6.388E-09 | 1.094E-13 | 1.267E-02 |
| 33 | 100.0 | 1.459E-16 | 5.397E-12 | 5.175E-12 | 1.041E-13 | 6.038E-20 | 3.852E-07 | 6.961E-12 | 2.007E-09 | 5.535E-11 | 2.300E-17 | 1.107E-04 |

FROM POINT - HEIGHT = 2.5000 KM, N = 3, NP = 0, REFRACTIVITY ABOVE AND BELOW X = 2.150E+02 2.284E+02

EQUIVALENT ABSORBER AMOUNTS PER KM AT X

6.125E-02 6.174E-01 1.741E-03 4.587E-01 3.157E-04 7.709E-01 1.231E-01 1.959E-03

FROM POINT - HEIGHT = 8.5000 KM, N = 9, NP = 0, REFRACTIVITY ABOVE AND BELOW X = 1.046E+02 1.122E+02

EQUIVALENT ABSORBER AMOUNTS PER KM AT X

2.615E-04 1.668E-01 3.626E-03 1.017E-01 6.591E-07 3.768E-01 2.101E-02 5.600E-03

VERTICAL PROFILES

| | | | | | | | | | | PSI | PHI | BETA | THETA | RANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 | 2.5 | 7.276E-02 | 7.290E-01 | 2.051E-03 | 5.419E-01 | 3.763E-04 | 9.090E-01 | 1.496E-01 | 2.309E-03 | -0.0001 | 115.0097 | 0.0096 | 64.9999 | 1.2 |
| 4 | 3.0 | 1.595E-01 | 1.910E+00 | 6.150E-03 | 1.392E+00 | 7.726E-04 | 2.528E+00 | 2.891E-01 | 7.164E-03 | 0.0021 | 115.0268 | 0.0269 | 64.9925 | 3.5 |
| 5 | 4.0 | 2.018E-01 | 2.665E+00 | 1.021E-02 | 2.059E+00 | 9.324E-04 | 3.969E+00 | 3.756E-01 | 1.222E-02 | 0.0046 | 115.0435 | 0.0481 | 64.9757 | 5.9 |
| 6 | 5.0 | 2.203E-01 | 3.641E+00 | 1.425E-02 | 2.583E+00 | 9.887E-04 | 5.256E+00 | 4.389E-01 | 1.751E-02 | 0.0069 | 115.0604 | 0.0674 | 64.9588 | 8.3 |
| 7 | 6.0 | 2.288E-01 | 4.267E+00 | 1.897E-02 | 2.992E+00 | 1.011E-03 | 6.402E+00 | 4.900E-01 | 2.405E-02 | 0.0090 | 115.0776 | 0.0869 | 64.9417 | 10.6 |
| 8 | 7.0 | 2.316E-01 | 4.766E+00 | 2.500E-02 | 3.308E+00 | 1.017E-03 | 7.415E+00 | 5.397E-01 | 3.285E-02 | 0.0110 | 115.0946 | 0.1058 | 64.9244 | 13.0 |
| 9 | 6.0 | 2.320E-01 | 4.977E+00 | 2.878E-02 | 3.438E+00 | 1.018E-03 | 7.876E+00 | 5.648E-01 | 3.860E-02 | 0.0124 | 115.1031 | 0.1154 | 64.9066 | 14.2 |

ESTIMATED TANGENT ALTITUDE = 920763.250 KM

EQUIVALENT SEA LEVEL ABSORBER AMOUNTS

| | WATER VAPOUR GM CM-2 | CO2 ETC. KM | OZONE ATM CM | NITROGEN (CONT) KM | H2O (CONT) GM CM-2 | MOL SCAT KM | AEROSOL KM | OZONE(U-V) ATM CM |
|---|---|---|---|---|---|---|---|---|
| W(1-8) = | 2.320E-01 | 4.977E+00 | 2.878E-02 | 3.438E+00 | 1.018E-03<br>6.013E-02 | 7.876E+00 | 5.648E-01 | 3.860E-02 |

| FREQ CM-1 | WAVELENGTH MICRONS | TOTAL TRANS | H2O TRANS | CO2+ TRANS | OZONE TRANS | N2 CONT TRANS | H2O CONT TRANS | MOL SCAT TRANS | AEROSOL TRANS | AEROSOL ABS | INTEGRATED ABSORPTION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2350 | 4.2553 | 0.0 | 0.9964 | 0.0 | 1.0000 | 0.6552 | 1.0000 | 1.0000 | 0.9902 | 0.0011 | 2.50 |
| 2355 | 4.2463 | 0.0 | 0.9969 | 0.0 | 1.0000 | 0.6642 | 0.9986 | 1.0000 | 0.9902 | 0.0011 | 7.50 |
| 2360 | 4.2373 | 0.0 | 0.9972 | 0.0 | 1.0000 | 0.6711 | 0.9972 | 1.0000 | 0.9902 | 0.0011 | 12.50 |
| 2365 | 4.2283 | 0.0 | 0.9973 | 0.0 | 1.0000 | 0.6758 | 0.9959 | 1.0000 | 0.9902 | 0.0011 | 17.50 |
| 2370 | 4.2194 | 0.0 | 0.9976 | 0.0 | 1.0000 | 0.6804 | 0.9945 | 1.0000 | 0.9901 | 0.0011 | 22.50 |
| 2375 | 4.2105 | 0.0 | 0.9975 | 0.0 | 1.0000 | 0.6804 | 0.9931 | 1.0000 | 0.9901 | 0.0011 | 27.50 |
| 2380 | 4.2017 | 0.0014 | 0.9981 | 0.0021 | 1.0000 | 0.6828 | 0.9917 | 1.0000 | 0.9901 | 0.0011 | 32.49 |
| 2385 | 4.1929 | 0.0272 | 0.9983 | 0.0406 | 1.0000 | 0.6828 | 0.9904 | 1.0000 | 0.9901 | 0.0011 | 37.35 |
| 2390 | 4.1841 | 0.1127 | 0.9987 | 0.1693 | 1.0000 | 0.6804 | 0.9890 | 1.0000 | 0.9901 | 0.0011 | 41.79 |
| 2395 | 4.1754 | 0.2546 | 1.0000 | 0.3853 | 1.0000 | 0.6758 | 0.9876 | 1.0000 | 0.9901 | 0.0011 | 45.52 |
| 2400 | 4.1667 | 0.4527 | 1.0000 | 0.6837 | 1.0000 | 0.6781 | 0.9863 | 1.0000 | 0.9901 | 0.0010 | 48.25 |
| 2405 | 4.1580 | 0.5831 | 1.0000 | 0.8775 | 1.0000 | 0.6804 | 0.9865 | 1.0000 | 0.9900 | 0.0010 | 50.34 |
| 2410 | 4.1494 | 0.6616 | 1.0000 | 0.9850 | 1.0000 | 0.6875 | 0.9868 | 1.0000 | 0.9900 | 0.0010 | 52.03 |
| 2415 | 4.1408 | 0.6724 | 1.0000 | 0.9940 | 1.0000 | 0.6922 | 0.9870 | 1.0000 | 0.9900 | 0.0010 | 53.67 |
| 2420 | 4.1322 | 0.6826 | 1.0000 | 0.9918 | 1.0000 | 0.7042 | 0.9873 | 1.0000 | 0.9900 | 0.0010 | 55.26 |
| 2425 | 4.1237 | 0.6869 | 1.0000 | 0.9874 | 1.0000 | 0.7115 | 0.9875 | 1.0000 | 0.9900 | 0.0010 | 56.62 |
| 2430 | 4.1152 | 0.6922 | 1.0000 | 0.9812 | 1.0000 | 0.7214 | 0.9878 | 1.0000 | 0.9900 | 0.0010 | 58.50 |
| 2435 | 4.1068 | 0.6951 | 1.0000 | 0.9739 | 1.0000 | 0.7339 | 0.9881 | 1.0000 | 0.9900 | 0.0010 | 59.87 |
| 2440 | 4.0984 | 0.7041 | 1.0000 | 0.9689 | 1.0000 | 0.7428 | 0.9883 | 1.0000 | 0.9899 | 0.0010 | 61.55 |
| 2445 | 4.0900 | 0.7131 | 1.0000 | 0.9660 | 1.0000 | 0.7543 | 0.9886 | 1.0000 | 0.9899 | 0.0010 | 62.73 |
| 2450 | 4.0816 | 0.7256 | 1.0000 | 0.9643 | 1.0000 | 0.7687 | 0.9888 | 1.0000 | 0.9899 | 0.0010 | 63.47 |

INTEGRATED ASORPTION FROM 2350 TO 2450 CM-1 = 63.47, AVERAGE TRANSMITTANCE = 0.3653

## APPENDIX D

## DEFINITIONS AND SYMBOLS

| | |
|---|---|
| AB | Absorption at frequency V; also average transmittance |
| AHZ1, AHZ2 | Aerosol number density |
| AJ | Equivalent absorber amount per km at level J |
| ALP | Angle of arrival at adjacent level |
| ANGLE | Input zenith angle (degree) |
| BET | Angle subtended at the earth's center as path traverses adjacent levels |
| BETA | Total angle subtended path at earth's center |
| BJ | Equivalent absorber amount per km at level J+1 |
| CA | Conversion factor from degree to radians |
| CO | Wavelength dependent coefficient used in refractive index expression |
| Cw | Wavelength dependent coefficient used in refractive index expression |
| C1 | Log absorption coefficient for water vapor |
| C2 | Log absorption coefficient for uniformly mixed gas |
| C3 | Log absorption coefficient for ozone |
| C4 | Absorption cofficient for nitrogen |
| C5 | Absorption cofficient for water vapor continuum |
| C6 | Extinction coefficient for molecular scattering |
| C7 | Extinction coefficient for aerosol models |
| C7A | Aerosol absorption coefficient |
| C8 | Absorption coefficient for ozone (UV and visible region) |
| D | water vapor amount (pr.cm/km) at level I |
| DP | Dew point temperature ( C) |
| Ds | Path length from level I to level I + 1 |
| DV | Wave number increment at which transmittance is calculated |
| DZ | Height increment from level I to I + 1 |
| E(K) | Equivalent absorber amount per km at height H1 |
| EH(1,I) | Equivalent absorber amount per km for water vapor at level Z(I) |
| EH(2,I) | Equivalent absorber amount per km for carbon dioxide, etc. at level Z(I) |
| EH(3,I) | Equivalent absorber amount per km for ozone at level Z(I) |
| EH(4,I) | Equivalent absorber amount per km for nitrogen at level Z(I) |
| EH(5,I) | Equivalent absorber amount per km for water vapor continuum at level Z(I) |
| EH(6,I) | Equivalent absorber amount per km for molecular scattering at level Z(I) |
| EH(7,I) | Equivalent absorber amount per km for waerosol extinction at level Z(I) |
| EH(8,I) | Equivalent absorber amount per km for ozone (UV and visible) at level Z(I) |
| EH(9,I) | Mean refractive index of layer above level Z(I) |
| EV | Integrated absorber amount from level I to I + 1 |
| FAC | Factor for exponential and linear interpolation |
| FO | Transmission function logarithmic absorber amount scale for ozone |
| FW | Transmission function logarithmic absorber amount scale for water vapor and uniformly mixed gases |
| H | Altitude (km) |
| H1 | Initial Altitude (km) |
| H2 | Final Altitude (km) |

| | |
|---|---|
| HAZE | Aerosol number density (no. cm-3) |
| HM | Estimated tangent height (km) |
| HMIN | Minimum altitude of path trajectory (km) |
| HZ1 | Aerosol number density (no. cm-3) for 23 km visual range |
| HZ1 | Aerosol number density (no. cm-3) for 5 km visual range |
| I | Running integer used as altitude indicator |
| IAERO | Indicator for type of aerosol model |
| IATOM | Number of levels in model atmosphere |
| IDV | Frequency increment (cm-1) |
| IFIND | Indicator for using subroutine ANGL |
| IHAZE | Aerosol model indicator |
| IM | Parameter used when reading in a new atmospheric model |
| IP | Indicator for using subroutine POINT to calculate reference index only (IP = 0) |
| IR | Card printer number |
| ITER,ITES | Iteration counters |
| ITYPE | Indicator for type of atmospheric path |
| IV | Frequency at which transmittance is calculated |
| IV1 | Starting frequency |
| IV2 | Last frequency |
| IW | Line printer number |
| IXY | Parameter for terminating program and cycling indicator |
| J | Running integer for altitude identification |
| JMIN | Altitude indicator for minimum height of path |
| JP | Print option for altitude H1 |
| J1 | Level indicator for altitude H1 |
| J2 | Level indicator for altitude H2 |
| K | Absorber indicator, K=1, 2, 3, etc., corresponds to water vapor, uniformly mixed gases, ozone, etc., respectively |
| K2 | Cycling parameter for downward looking paths |
| L | Frequency indicator for ozone transmittance calculation |
| LEN | Parameter used for defining longest of two paths |
| M | Integer used to identify required model atmosphere |
| ML | Number of levels in radiosonde data input (MODEL7) |
| MODEL | Integer used to identify required model atmosphere |
| M1 | Integer for selecting temperature altitude profile for (M=M1) |
| M2 | Integer for selecting water vapor altitude profile for (M=M2) |
| M3 | Integer for selecting ozone altitude profile for (M=M3) |
| N | Indicator for level below given input altitude used in POINT subroutine |
| NL,NLP | Number of levels in model atmosphere data |
| NP | Indicator for determining whether H1 or H2 coincide with levels in the model atmosphere |
| NP1 | Value of NP for altitude H1 |
| NP2 | Value of NP for altitude H2 |
| NS1,NS2 | Counters corresponding to WS1, WS2 |
| P(M,1) | Pressure (mb) at level I for model atmosphere M |
| PHI | Angle of arrival at H2 |
| PPW | Partial pressure of water vapor (in atmosphere) |
| PS | Total pressure in atmospheres |
| PSI | Angular deviation of path from initial direction |
| PT | Product of total pressure (atm) and the square root of 273/T(M,I) |
| RANGE | Path length (km) |
| RE,REATH | Earth radius (km) |
| REF | Refractive index of air at level I |
| RH | Relative humidity (%) |
| RN | Ratio of refractive indices of air above and |

below a given level

| | |
|---|---|
| RX | Ratio of earth center distances between adjacent levels |
| RO | Earth radius (km) read in as input (=RE) |
| R1 | The product of the sine of the initial zenith angle and the earth center distance to starting altitude |
| SALP | Sine of angle of arrival at adjacent level |
| SPHI | Sine of the local zenith angle at a given level |
| SR | Slant range (km) |
| SUM | Accumlated absorption |
| T(M,I) | Temperature (K) for model atmosphere M at level I |
| THET | Zenith angle at a given level (in radians) |
| THETA | Zenith angle at a given level (in degrees) |
| TMP | Ambient temperature (C) |
| TR | Transmittance scales for transmission functions |
| TS | Ratio of standard temperature (273.15 K) to temperature level I |
| TS1 | Ratio of 296 K to temterature at level I |
| TT | Ratio 273.15/(TMP + 273.15) |
| TX(K) | Equivalent absorber amounts per km at a given altitude obtained from POINT; also transmittance values at a given wavelength for each absorber type (K = 1,8) |
| TX(9) | Total transmittance at frequency IV |
| TX(10) | Absorption due to aerosol only at frequency IV |
| TX1 | Refractive index of layer above initial alt. H1 |
| TX2 | Refractive index of layer above final alt. H2 |
| TX1 | Refractive index of layer above minimum alt. HMIN |
| VH(K) | Integral of the equivalent absorber amounts from H1 to level I |
| VIS | Visual range (km) at sea level |
| VX | Wavelength at which aerosol coefficients are read in (micrometer) |
| V1 | Initial frequency for transmittance calculation |
| V2 | Final frequency for transmittance calculation |
| W(K) | Total equivalent absorber amount for entire path |
| WH(M,I) | Water vapor density for atmospheric model M at level I (gm m-3) |
| WL,WL1,WL2 | Wavelength in microns |
| WO(M,I) | Ozone density for atmospheric model M at level I |
| WS1 | Transmission function scaling factor for water vapor at given wavelength |
| WS2 | Transmission function scaling factor for carbon dioxide, etc., at given wavelength |
| WS3 | Transmission function scaling factor for ozone at given wavelength |
| X | Input height to POINT subroutine |
| XI | Wavenumber interpolation parameter |
| XX | Wavenumber identification parameter for UV ozone transmittance calculation |
| X1 | Earth center distance of level I |
| X2 | Earth center distance of level I + 1 |
| YN | Refractive index of layer below input height from POINT subroutine |
| YN1 | Refractive index of layer below initial alt. H1 |
| YN2 | Refractive index of layer below final alt. H2 |
| YY | Aerosol absorption coefficient at frequency V |
| Z(I),ZO(I) | Altitude at level I in km |

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